A

COURSE
OF
LECTURES

IN THE

Moſt EASY, USEFUL, and ENTERTAINING PARTS

OF

Geography, *Aſtronomy*, *Chronology*, and *Pneumatics*;

As they are deliver'd, by Way of TEXT,

TO THE

YOUTH

OF THE

ACADEMY

At the HEATH, near *Wakefield*, YORKSHIRE.

By *JOSEPH RANDALL*,

MASTER of the ſaid ACADEMY.

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M,DCC,L.

BRITISH MUSEUM

To the Young GENTLEMEN of the ACADEMY.

THE general Diſpoſition, I have obſerv'd in you, of devoting ſome of your leiſure Hours, to the Study of ASTRONOMY *and* PHILOSOPHY, *gives me the higheſt Pleaſure; becauſe this Kind of Education is not only of great* Importance *in the Concerns of Life, but, alſo, has a natural Tendency to inſpire you with becoming Sentiments of the Divine Being.*

And, if the Britiſh Youth, *in general, were to dedicate proper Hours to theſe* intereſting Studies, *the Riſing Generation, whereof they are the Plants, would find the happy Effects of them.*

That you, by your Improvement in Virtue and Knowledge, may be a Bleſſing to your Parents, and your Country, is the ſincere Wiſh of,

HEATH,
Dec. 20,
1749.

GENTLEMEN,

Your moſt affectionate Friend,

JOSEPH RANDALL.

THE PREFACE.

THE Reader is not to expect any material Improvements in the following Treatiſe; the Deſign whereof is only to introduce Youth, by eaſy Methods, to an early Acquaintance with thoſe Parts of Knowledge; and to mend the Heart, by endeavouring to inſpire their tender Minds, with the Magnificence and Uſes of the viſible Works of God, their great Benefactor.

AS this Subject has exerciſed the Attention of many great and good Men, who have had the Education of Youth much at Heart; I have made no Scruple of borrowing any Aſſiſtance from thoſe Writers, that have fallen in my Way: Not only as to Sentiment, *but even Expreſſion; and have frequently made great Alterations, to accommodate them to my Purpoſe. The greateſt Part of that Piece, which gives the Uſes of the* Orrery, *was ſent me by the Perſon of whom I bought the* Machine; *I have made ſome Additions and Alterations therein, to ſerve my Deſign of adapting every Thing to the Apprehenſions of Youth, and the better to convey the Inſtruction.*

THE following little Piece is to be conſider'd as the Text, which, at theſe Meetings, is fully explained in other Words, familiar Compariſons, and every Particular illuſtrated, when it can be done, with Machines and Inſtruments, and entertaining Experiments, as beſt ſuits with the different Ages and Abilities of Youth.

LECTURES
IN
Geography, *Aſtronomy*, and *Philoſophy*.

CHAP. I. GEOGRAPHY.

GENTLEMEN,

Geography.

IN the courſe of theſe Lectures I ſhall endeavour to explain, and as much as poſſible bring within the reach of your Capacities, ſome things in Geography, Aſtronomy, and Philoſophy, which are moſt neceſſary to be known. And tho' you may not, perhaps, be capable of comprehending the reaſons of ſome things, yet it may be of great advantage to you to know the things themſelves as they are: The plain and ſimple truth ſhall be laid open to you; and every particular illuſtrated, when it can be done, with ſuch entertaining Experiments, and familiar Compariſons, as ſuit your age, or have fallen under your obſervation.

You ſee the Heavens over your heads, and tread on the Earth with your feet, but you are at a loſs what to think of that mighty Concave above you; the changes

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that happen there, and every glorious object ſeen there, perplex you with fruitleſs gueſſes. What means that multitude of glittering Stars ſcatter'd over the face of the whole Heavens! Who placed them there, and for what Purpoſe! When you ſee a curious Clock or engine, you preſently conclude that it was made and contriv'd by ſome artiſt: And when you come to contemplate the great variety, order, beauty, and uſefulneſs, which will appear in the works of God, you will conclude that the whole are contriv'd, fram'd, and faſhioned by a wiſe and powerful Being. Then as to the Earth you walk upon; you often think, whether it may not ſtretch out in breadth, ſo that if you were to begin your journey, you ſhould always find room to continue travelling on, till you come where the Sky and Earth touch each other.——Nor can you ſatisfy yourſelves as to the depth of the Earth, whether it hath any bottom, and if ſo, what it is that can be below the Earth?

The Earth you live upon is a great Globe, like this before you, which is a repreſentation or picture of it, and only differs from it in ſize. The *Engliſh*, *Dutch*, *Spaniards*, and *French*, have often ſailed round the Globe of the Earth. You muſt not imagine it might be as when a man is ſaid to ride round a country, or walk round a field; it is as if ſome little Reptile, an Ant, for inſtance, ſhould travel round this Globe before us, in her creeping pace, going off towards the Right hand, and returning from the Left. But if the Earth were endleſly broad, or deep without bottom, or if it reſted on any thing, and that thing upon another, and ſo on; could the Earth, think you, be ſailed round, or the Ship return from the Left hand, when ſhe had ſet off, and gone towards the Right? Theſe voyages, ſo often perform'd, cannot admit of any doubt; unleſs we would expoſe ourſelves, by a ridiculous doubting of plain fact. Theſe Navigators, while they were in the oppoſite part of the Globe, juſt where my finger is, beheld the Heavens over their head, and ſaw the Sun and Stars perform their courſes, and that Day and Night ſucceeded each other there, as well as here. The Sun then muſt move round the Earth every day, and give Light alſo to that part of the World oppoſite to us.——You perhaps will ſay, if there be any inhabitants, they walk with their heads downwards, and what can hinder them from falling down altogether? They have the very ſame reaſon to be afraid of you, leſt you ſhould fall off from the Earth. Navigators, when they were in thoſe places, were in no danger of falling upwards, as the Heavens were over their heads; they knew the weight of the Ship there, as well as here, hinder'd it from falling from the Sea up to the Clouds. Which do you think now is the loweſt place of all? If we ſuppoſe a paſſage through the Earth from the oppoſite part to us, and a Cannon-Ball ſuſpended at an equal diſtance betwixt them and us, you may imagine it cannot come to us, that would be to fall upwards; and thoſe people will ſay it cannot go to them, as that is equally unnatural; ſo then the Centre of the Earth is the loweſt place, below which nothing can be lower. For if two ſtones were let down at the ſame time from the oppoſite mouths of the paſſage, they would move oppoſite to each other, and meet at the loweſt place or centre, and there remain; and all bodies in the ambient ſpace, in oppoſite parts all round the Globe, would perform the ſame, if they were not prevented by the ſurface of the Earth; that is, if there were paſſages made for them to deſcend, as before.——What do you think can be the cauſe of ſtones, or heavy bodies, thus falling, or ruſhing ſo violently to one point, the center, provided they have a free paſſage? You cannot think they can thus move of themſelves; and if ſo, what gives them this motion?—I eaſily gueſs at what paſſes in your minds; you begin to be awaken'd from that ſupine thoughtleſsneſs, which makes the greateſt part of Youth, nay of Mankind too, look on things, *aſtoniſhing in themſelves*, with indifference, becauſe they ſee them conſtantly. To come at a view of the true conſtitution of nature, begets a manly and rational pleaſure in the ſoul, quite different from the pleaſures you find in your diverſions: And this rational entertainment is peculiar to man, and chiefly conſtitutes the difference between him and brutes; for they partake, with him, of the pleaſures that immediately flow from bodily ſenſes and appetites. Suſpend your judgment at preſent, till we take a general view of the Earth, both outward and inward; ſur-

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There are ſeveral ſorts of valuable Metals, precious Stones, and many other materials, which are conſtantly employ'd for our uſe, and were deſign'd to be a never-failing treaſure for the ſervice of all ſucceeding ages: Theſe are carefully lock'd up in the vaſt ſtorehouſes under our feet, where we are ſure to find them in all caſes of neceſſity. Providence has ſo wiſely order'd it, that they are not buried at ſuch a depth as to make them inacceſſible by us; but at a proper diſtance below the ſurface. It is certain, that God might have placed all theſe riches on the ſurface, to be near at hand and ready to be employ'd on all occaſions, but then the vaſt quantity of them would have almoſt cover'd the Earth: Whereas now, the ſurface of the Earth is diſengag'd of thoſe embarraſſments, which would otherwiſe obſtruct all Huſbandry. Were there not proper coats of Earth above theſe materials, the ſoil could not bring forth proper proviſions for the uſe of man and beaſt; but by this piece of natural oeconomy we enjoy great advantage, the external parts of the ground yielding us proper crops, and the internal furniſhing us with variety of rich materials, abſolutely neceſſary to man in his needy ſtate, and in order to procure him a decent and commodious habitation, and to ſupply his other exigencies.

Theſe places on the Globe before us, are the repreſentations of vaſt Mountains ſcatter'd up and down the ſurface of the Earth. You muſt not look upon them as ſo many ſhapeleſs protuberances ſcatter'd about the Earth.

Earth at random, without all deſign or intention to produce any advantage to mankind. I think, I cannot take any better method, to excite your admiration, than by *convincing* you (which ſhall be done in a more proper place) of the ſurprizing uſefulneſs of them. I ſhall prove to you, that without the aſſiſtance of Mountains, mankind, animals, and plants, muſt die for want of moiſture; for without them there can be no fountains, ſprings, or rivers, for the ſupport of needy life. Their tops are deſign'd to collect the vapours that fluctuate in the Atmoſphere; the intermediate ſpaces betwixt their ſummits are ſo many baſons prepar'd to receive the rains that fall into them, by the aſſiſtance of thoſe tops; their bowels are ſo many common ſtorehouſes or reſervoirs of Water for our uſe. As for the rains that deſcend immediately upon the plains, they either ſoon run off them, or evaporate; whereas Mountains feed them with conſtant ſupplies, as the all-wiſe Creator has contriv'd ſuch vaſt magazines in the Clouds above them, from which he ſhowers down his treaſures of Water upon their ſummits, which afterwards deſcending from ſtory to ſtory, diffuſes its refreſhing ſtreams over the plains below, gives life and verdure to the Plants and Herbs, and beautifies and enriches the whole Earth. Beſides theſe ineſtimable benefits we receive from the Mountains in thoſe ſprings and rivers, which diſtil from them, they are a refuge of an infinite number of Animals, that are of great uſe to us, which feed upon them, freeing us from all care or charge about their maintenance: Nor are the Hunters the only ſet of men that pay their viſits to theſe Mountains, when in purſuit of their game; but hither alſo the Herbaliſt comes, to ſeek for wholſome Simples, which either are not to be found elſewhere, or at leaſt, thoſe that grow here are in greater perfection, and have a more medicinal virtue than thoſe planted in Gardens.

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The extenſive Meadows, which are diſperſed over the face of the Earth, are, in reality, the places where Nature has ſhew'd herſelf benevolently complaiſant to man; where ſhe does at once exhibit the greateſt beauty and fecundity together——But the chiefeſt benefit we reap from the Meadow is, that it does, at its own expence, Geography. pence, afford proviſion for thoſe Animals, whoſe ſervice we ſtand in much need of.

How graceful an appearance does the courſe of a River make in the works of Nature! How uſeful to needy creatures! Every country ſets a high value upon the River it is enrich'd with; and you may eaſily conceive the great diſtreſs thoſe people are in, that want ſo great a bleſſing. In all Continents, and even in the ſmalleſt Iſlands, there are Mountains, at different diſtances from one another, ſome higher, ſome lower, from which there lies a gradual deſcent to the ſhore; the ſources of Rivers being purpoſely lodg'd in the bowels of theſe eminences, that the waters, by having a proper deſcent, may be thrown into the Sea.

The vaſt and prodigious cavity, which we call the Channel of the Ocean, runs quite round the Globe, and reaches for ought we know from Pole to Pole, and is in many places unſearchably deep: And from the teſtimony of Mariners, there are in it, under water, Mountains and Vallies, Rocks and ridges of Rocks, as upon the Land. When we preſent this ſtrange gulph to our imagination, emptied of its waters, naked and gaping at the Sun, ſtretching its jaws from one end of the Earth to another, with what amazement ſhould we ſee it under us like a wide bottomleſs Pit! There are alſo Caves and hollow paſſages running into the very bowels of the Earth, by which the Seas communicate one with another, and with ſubterraneous waters. Thoſe great Whirlpools, that are in ſome Seas, which ſuck into them, and overwhelm whatever comes within their reach, ſhew that there is ſomething below, that ſucks from them in proportion, and drinks up the Sea, as the Sea drinks up the Rivers. This element is ſubject to every little impreſſion from the Winds, which act upon it; ſo that we find it almoſt perpetually changing its form. Sometimes you will perceive an univerſal calm, its Waters ſtill, its ſurface appearing like a flattering glaſſy plain, reflecting another Heaven, with its Sun, its Azure, and its Clouds. On a ſudden you may perceive it grow angry and boiſterous, opening its wide jaws into a terrible abyſs, or, with proud billows, daſhing the face of Heaven; ſome waves breaking with great violence againſt the ſhores, cauſing great tumult and confuſion to the poor diſtreſs'd Mariners, amidſt thoſe mountains of water, lamenting their ſad condition! In the midſt of ſuch a diſmal ſcene, we could expect nothing leſs than a fatal deluge, were it not that the ſame Almighty Hand, which lifted up the waters thereof, has ſet it bounds which it cannot paſs.

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There is a remarkable motion of this element well worth your notice. The water of the Ocean flows in general ſix hours together, from theſe ſouthern parts here where I point, towards the northern parts, and riſes on the coaſts more or leſs; this we call Flood: When it is at its greateſt height, or high water, it remains at that pitch about a quarter of an hour, and then retires, continuing to decreaſe ſix hours; and after remaining at its loweſt ebb about a quarter of an hour, it makes again to land. The benefit which God deſign'd for man, by this motion of the waters, was to prevent their corrupting, and thereby breeding any infection that might ariſe from too long a ſtagnation of them: He has not committed this truſt to the uncertain care of the Winds, which he appointed to purify the air we breathe, and to facilitate the productions of the Earth, by the diverſity of its impreſſions and influences. Tho' the Winds are not leſs uſeful upon the Sea in tranſporting our merchandize, with more eaſe and expedition than the beſt Horſes could poſſibly do by land; yet their blaſts are very uncertain, and oftentimes ſucceeded by long calms, which would ſoon breed putrefaction in the Sea, that great receptacle into which all the ſinks and drains of the Earth diſcharge themſelves. God has been pleaſed to ſuperadd to thoſe irregular and interrupted purgations of the Winds, theſe diurnal helps of the flux and reflux of the tides, which cauſe the rivers alſo to flow back to a certain diſtance; by which increaſe of waters large Ships of burden are brought up to great towns, which, without this flowing of the rivers, would be impracticable.

If we could go down into the bowels of the Earth, we ſhould there ſee dark chambers and apartments; ſtrange

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ſtrange ſubterraneous paſſages, holes and caverns, ſome fill'd with ſmoak and fire, ſome with water, and ſome with vapour and mouldy air; little brooks run murmuring through the dark grottoes. There alſo appears a ſurprizing mixture of ſubſtances in the very bowels of the Earth; maſſes of petrified wood, brick, wrought metals, beds of ſea-ſhells, trees, and marine bodies buried under great ruins; and theſe not in particular places, but throughout the whole Earth; not only in the lower grounds, and hillocks near the ſhore, but in the higheſt mountains far diſtant from the Sea.——You may probably deſire to know how it came to paſs, that thoſe marine animals, which formerly inhabited the great deep, are now ſound buried under ſeveral layers of Earth, at a conſiderable diſtance from the Sea, and from the ſurface of the Earth: Theſe have been generally thought the effects of ſome great event, ſome terrible change in Nature. The Scripture informs us, that God cauſed an inundation to be brought upon the Earth in the days of *Noah*, for the puniſhment of a wicked World, that overſpread the face of the whole Earth; and in ſuch exceſs, that the floods over-reach'd the tops of the higheſt mountains, the rain deſcending after an unuſual manner; ſo that a general deſtruction and devaſtation was brought upon the whole Earth and its inhabitants. The amazing agitation and fluctuation of the vaſt waves, rolling for many months together on the outward frame of the Earth, muſt have made ſtrange havock, levelling vaſt mountains, and raiſing others. This univerſal diſorder might occaſion that mixture of bones of animals, maſſes of broken metals, and ſundry works of human art, together with the ſhells and teeth of Fiſhes, and other productions of the Sea. Several parts of the Earth muſt alſo have been undermin'd by the raging waves, and the mountains in many places have tumbled down on the plains, burying under their ruins thoſe marine bodies, which were intercepted by this fall. Whatever we can diſcover either upon or within the Earth, ſufficiently proves to you the truth of thoſe facts which are related by the divine hiſtorian. Earthquakes indeed produce the like effects, making havock upon the face of the Earth; and turning things upſide down. But we do not read that there have been ſuch frequent and univerſal repetitions of theſe diſmal events, to infer, that they have thus turn'd the earth, as it were, inſide out; and things of this nature, being both ſtrange and ſenſible, excite admiration and great attention when they come to paſs, and would certainly have been remember'd or tranſmitted down, in ſome way or other. **Geography.**

Theſe Earthquakes are evident demonſtrations, that there are in the very bowels of the Earth ſtrange vacuities; for if the inward parts of the Globe were ſound and compact, there would be no ſuch thing in nature.——They are commonly accompanied with a heavy dead ſound, like a dull thunder, that ariſes from the vapours that are ſtriving in the womb of nature, when her throes are coming upon her. There are quantities of exhalations, and magazines of combuſtible matter, treaſur'd up in theſe dreadful hollow paſſages, that are capable of rarefaction and inflammation; and when the vapours come to be ſtreightened, they ſtrive every way to ſet themſelves at liberty, and often break their priſons, or the cover of the Earth that keeps them in, which Earth upon that diſruption falls into the ſubterraneous caverns. That theſe caverns and trains, where the vapours lie, are very large and capacious, we are taught by ſad experience, for whole Cities, Countries, and Iſlands, have been ſwallow'd up into them.

England. Let us now take a ſurvey of the Earth, as it is inhabited by mankind. This place on the Globe is *Great Britain*, containing *England* and *Scotland*; the capital city of the former is *London*, at the diſtance of about 300 miles ſouth of *Edinburgh* the capital of the latter. The *Engliſh* bear the character of being generous and ſincere, upright in their dealings, and induſtrious; ingenious, learned, and of a ſolid judgment. The fair Sex are modeſt, provident and temperate; good-natur'd, ſincere, and zealous in religious Devotion. **Scotland.** The natives of *Scotland* have a clear underſtanding, are ſagacious, induſtrious, and frugal; very temperate in eating and drinking, even in Countries where luxury and exceſs in both are too much practis'd. The Gentlemen are all well bred, and as generally learned as any country in *Europe*; quick at finding out their intereſt, and diligent in purſuing it; very dextrous in acco-

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Ireland.

modating themſelves to the manners of the people with whom they live.——This place is *Ireland*, belonging to the King of *Great Britain*; its capital city is *Dublin*, at the diſtance of about 250 miles north-weſt of *London*. The Gentlemen are generally well bred, and very civil to ſtrangers, and want neither ſkill nor courage to attempt the moſt difficult enterprizes: And, of the people in general, it may be allow'd that no better people are to be found: Indeed thoſe that are bad, are ſaid to be exceeded by few in wickedneſs of any kind.

Spain.

This is *Spain*, whoſe capital city is *Madrid*, ſituate about 690 miles ſouth from *London*.—The *Spaniards* are men of a piercing wit, and elevated genius; but very little improv'd by ſtudy or converſation, for want of ſchools and academies, where the ſciences are taught in the modern way. They are admir'd for their ſecrecy, conſtancy, and patience in adverſity; are very ſlow in determining, but uſually conclude judiciouſly at laſt: They are generous, magnificent, liberal, delicate in the point of honour, ſincere friends, agreeable companions; grave in diſcourſe, great enemies to lying, and extremely temperate in eating and drinking; obedient and faithful to their King, whom they never mention but with the utmoſt reverence, very devout in offices of piety, and very civil to ſtrangers.

Portugal.

This is *Portugal*, and *Liſbon* here is the capital city, about 840 miles ſouth-weſt of *London*. The *Portugueſe* are men of a good genius; the nobility and gentry are magnificent, liberal, temperate in eating and drinking; charitable, relieving people in diſtreſs of every nation and religion without exception.

France.

This is *France*, and this *Paris*, the capital city, about 203 miles ſouth-eaſt of *London*. The *French* have a great veneration for their King; they have a genius fit to undertake any thing, whether it be in Learning, Trade, War, or Manufactures; they are very civil, ſprightly, and active; bleſſed with a clear conception, and ready expreſſion; extremely complaiſant and obliging to foreigners; pleaſing in diſcourſe, of a graceful and winning deportment. They have of late advanced Learning to a very conſiderable height, and have produced ſeveral authors, (and even ſome of the fair ſex) who are now famous through all the learned World, for their ſingular parts. Geography.

Italy. This is *Italy*, the capital is *Rome*, about 780 miles ſouth-eaſt from *London*. The *Italians* are exceeding complaiſant, and obliging to each other, and very affable to foreigners; they are as ſober a people as are to be found in the chriſtian World, tho' they abound in plenty of choice wines. They are generally men of wit, and have a genius for arts and ſciences; nor do they want application.

Germany. Here is *Germany*, whoſe capital is *Vienna*, about 650 Miles eaſt of *London*. The natives are allow'd to be endow'd with ſome very commendable virtues, particularly honeſty, fairneſs in their dealings, and hoſpitality, which the ancient as well as the modern *Germans* are allow'd to have. *Julius Cæſar* informs us, that in his days, their houſes were open to all travellers; and look'd upon it as a piece of injuſtice to affront a ſtranger. They are allow'd to be excellent Mechanics and Chymiſts; nor do their Scholars come behind the Mechanics in their unwearied application to their ſtudies. They are indeed, by the *French*, charg'd with being dull; but if nature has been bountiful to the *French*, in giving them a happy conception, the want of this in the *Germans* is made up to them in a good judgment. As to the honeſty and integrity of the *Switzers*, for which they have been ſo generally applauded, late writers aſſure us, they do not altogether deſerve ſuch a character at preſent; but, however, are yet brave in Arms, and faithful to their engagements, as mercenaries, or allies. The *Hungarians* here are a brave warlike people, wiſe and politic, and zealous aſſerters of the chriſtian faith. Theſe are the Dominions of the King of *Pruſſia*, whoſe chief city is *Berlin*, 270 miles north of *Vienna*. They are eſteem'd excellent Soldiers, and in all other reſpects, deſerve the ſame character, nearly, with the reſt of the *Germans*.

Holland. Here you have *Holland*, or the *United Provinces*, which are a Confederacy of many independent States. Here is *Amſterdam* the capital, ſituated about 132 miles eaſt of *London*.

Geography. The loweſt claſs of the people in this country are induſtr ous, but ſlow of underſtanding; not to be dealt with b haſty words, but eaſily manag'd by gentle expreſſions, and yielding to plain reaſon, if they have time to underſtand it. The trading people in great Towns are reckon'd plain, honeſt dealers, punctual in every reſpect, pondering and ordering a thing very well before they begin it. The Gentry, or Noblemen, are an honeſt, frugal, good ſort of men, and uſually acquit themſelves with honour, in the ſervice of their country.

Denmark. This is *Denmark*, whoſe capital is *Copenhagen*, 480 miles north-eaſt of *London*. The *Danes* are the remains of an illuſtrious nation, which in former times made a great figure in the World. The preſent natives are laborious and content with little; are allow'd to be a brave, ingenious people, and not to come behind their neighbours in good qualities.

Norway. Lapland. This is *Norway* belonging to the *Danes*, and the chief town is *Bergen*. This is *Lapland*, and this *Iceland* belonging to the ſame King: The *Norwegians* are ſaid to be but an ignorant ſort of people; a people however that are very hardy and laborious, exceeding juſt in their dealings, and obliging to ſtrangers. The *Laplanders* are a very innocent and ſuperſtitious people, ſcarce guilty of any of the vices of their politer neighbours. Iceland. The *Icelanders* are reckon'd a very ignorant and ſuperſtitious people, and value themſelves much for their great ſtrength.

Sweden. The *Swedes*, here, whoſe country this is, have a ſort of gravity not unbecoming; they have a great inclination to make a grand appearance, by which many of them ruin their families; they are a people very religious, and conſtant frequenters of the church; they are much given to hoſpitality, very affable and civil to ſtrangers. The Nobility, who apply themſelves chiefly to a military life, are famous for their courage and bearing hardſhips. The common Soldiers endure cold, hunger, and hard marches, to admiration, and are rather valuable upon account of their courage and obedience, than learning their duty readily. This city here, *Stockholm*, is the capital, of all this King's dominions, 720 miles north-eaſt of *London*.

Here

Ruſſia.

Here you have the extenſive dominions of *Muſcovy*, or *Ruſſia*, whoſe chief cities are *Peterſbourg* and *Moſcow*; the former 1080 miles north-eaſt of *London*. The temper of the *Ruſſians* is not much admir'd: They are held to have good parts, and capable of imitating any thing they ſee done: They, 'tis ſaid, value themſelves in over-reaching one another; for the terms honeſt man and a fool are, with them, of the ſame import: They are ſlothful, proud, and deceitful; and can hardly be brought to learn any art or ſcience without the diſcipline of the whip; are bleſſed with a hale and vigorous conſtitution. I am ſorry to meet with no better character to give you of theſe people.

Poland.

This is *Poland*, whoſe capital is *Warſaw*, 766 miles eaſt of *London*. The genteeler part of the natives are commonly reckon'd downright and honeſt, very ſeldom given to the art of diſſembling; they are of a very generous ſpirit, but expect a great deal of reſpect. The people in general are very fierce, much inclin'd to an uncontroul'd liberty, or rather licentiouſneſs and petulancy; Wherefore plots and conſpiracies againſt their Kings are frequent among them, whoſe actions they canvas with a great deal of freedom, being always too jealous of the leaſt point of their liberty. They do not want courage, but are more fit to act with a ſudden heat than to endure long the fatigues of war.

Turkey.

Theſe countries are what make up the *Turkiſh* Empire, whoſe capital is *Conſtantinople*, 1300 miles ſouth-eaſt of *London*. The *Turks* are perſons of integrity in their dealings, ſtrict obſervers of their word, very civil to ſtrangers, and extraordinary charitable: They are commended for paying a profound reſpect to every thing that is ſacred, and the ſtrict obſervance to the hours of prayer, and the devotion with which they offer them up: The frugality and temperance of the *Turks* are frequently mention'd by travellers for our imitation.

Arabia.

This is *Arabia*, whoſe capital is *Mecca*, 2640 miles ſouth-eaſt of *London*. The *Arabians*, near *Muſcat*, here, are reckon'd brave, and of a civil and honeſt deportment,

to

Geography. to all ſorts of people. The natives in general, in the other parts of this country, are much taken notice of for their rambling from place to place; and this not in ſmall parties only, but alſo, in many places in great companies, with their Prince at their head.

Perſia. Here is *Perſia*, and this *Iſpahan* the famous capital, 2556 miles eaſt of *London*. The *Perſians* are generally acknowledged to be men of bright parts, and abundance of vivacity, fond of glory, and very courageous; and as they were formerly obſerv'd to be the moſt civil and obliging of all men, they retain the ſame happy diſpoſition to this day, eſpecially to foreigners, who admire their hoſpitality, benevolence, and the great command they have of their paſſions. They are great enemies to fraud, are meek, peaceable, and modeſt. Amongſt their ſtudies, Moral Philoſophy ſeems to be more cultivated than the reſt. Theſe people ſhew a perfect reſignation under all misfortunes, and ſpeak of death, and ſuffer it, with great evenneſs of temper; as moſt moral virtues ſeem to be deeply impreſs'd on their minds.

India. This is *India*, whoſe capital city, *Agra*, is 3780 miles eaſt of *London*. The inhabitants of this vaſt Empire are to be diſtinguiſh'd into *Moors* or *Moguls*; and *Pagans* or original *Indians*. The *Moors* or *Moguls* are a mixture of *Tartars*, *Perſians*, and *Arabs*, whoſe characters may be ſeen under their reſpective heads. The original *Indians*, who are by much the greateſt number of the inhabitants of this Empire, are certainly as polite and ingenious a people, and as peaceable, humble, inoffenſive in their behaviour, as are to be found on the face of the Earth: They are alſo extremely tender and compaſſionate, even to animals and the vileſt inſects. As for courage, they are not very remarkable; however, few people preſerve a more equal temper at the approach of death. The natives of *Siam*, which is a part of *India*, have a ready and clear conception, and their repartees are quick and ſmart; they imitate any thing at ſight very well; and are neither laſcivious or intemperate; nor will wanton diſcourſe paſs for wit, or be taken for ſublimity of genius: They are polite and courteous, and their minds are always calm, being bleſſed with a great command of their paſſions.

They

Geography. They are great lovers of their families, and their children are ſaid to be very engaging and of a ſweet temper.—— The *Tonquineſe*, another people of this vaſt Empire, are courteous and obliging to ſtrangers, eſpecially the trading part of them, and mighty fair dealers; very ingenious and diligent, and patient in adverſity.

China. Here is the vaſt Empire of *China*, whoſe capital city is *Pekin*, 4380 miles ſouth-eaſt from *London*. The *Chineſe* are a very polite ingenious ſort of people; but it ſeems they uſe ſuch art to conceal their vices, that a ſtranger would be eaſily induc'd to believe they are all men of ſtrict virtue. They continually apply themſelves to diſcover the inclinations, humours, and tempers of thoſe they have any commerce with; and no people know better how to inſinuate themſelves into the good opinion of thoſe they deal with.

Great Tartary. All this vaſt country is call'd *Great Tartary*; this belongs to the *Chineſe*, this to the *Ruſſians*, and this to ſeveral independent Princes. *Chinyan* is the capital of *Chineſe Tartary*, 4480 miles eaſt of *London*. *Samarchand* is the chief city of *Independent Tartary*, 2800 miles eaſt of *London*. *Tobolſky* is the chief city of *Muſcovite*, or *Ruſſian Tartary*, 2412 miles north-eaſt of *London*. We know very little of the character of the inhabitants of this vaſt country, that can be depended on, only that the *Tartars*, in the road from *Tobolſky* to *China*, are reckon'd more ſubſtantial than the neighbouring parts, and very hoſpitable. The *Circaſſians* are alſo extremely civil to ſtrangers that travel that way, and will not ſuffer them to pay any thing for the entertainment of themſelves, horſes, or ſervants; but will even contend frequently who ſhall have the honour of treating them, The *Japaneſe*, who are the natives of this iſland, are reckon'd very fair in their dealings, and very ingenious; of quick apprehenſion, and good underſtanding, modeſt and courteous; they are careful to inſtil into the minds of their children a love of glory and virtue, and are not covetous of much Riches, contenting themſelves with a competency. They obſerve a decorum in their common converſation, avoiding all looſe or vain expreſſions, and detraction. *Jedo* is the capital city, 4950 leagues from *London*. The natives of theſe, call'd the

Geography.

the *Philipine Iſlands*, are an ingenious witty people, civil to ſtrangers, and make a genteel appearance. The *Javaneſe*, here, are very abſtemious, and have the character of being fierce and haughty. The people of *Macaſſar* have excellent memories, and are very quick of apprehenſion: They ſeem to be bleſſed with juſt notions of honour and friendſhip; and there are inſtances of many of them, who have reliev'd and maintain'd people in diſtreſs, and even ſuffer'd them to ſhare their eſtates. They are, it is true, unhappy in being very ſubject to paſſion; but it is ſoon over, and then they will condemn themſelves for not conquering that weakneſs. There are no people more addicted to arms and hardy enterprizes, enduring fatigues as well as any people whatever. The inhabitants of this iſland, call'd *Borneo*, are in general quick of apprehenſion, and extremely inquiſitive, and will learn any thing with a great deal of eaſe. They are held to be people of a very peaceable diſpoſition, and ſeldom or never quarrel. The people of this iſland of *Sumatra*, do not ſeem to have any thing of a character like ſome of the former; they are ſaid not to want genius, but diligence to apply themſelves to arts and ſciences. The people of *Ceylon* do not want courage, and are men of quick parts, complaiſant and inſinuating in their addreſs; naturally grave, and of an even temper, not eaſily mov'd; and when they happen to be in a paſſion, ſoon reconcil'd again; are very temperate in eating and drinking, and do not indulge in their ſleep.

Egypt.

We come now to *Egypt*, whoſe chief town is *Grand Cairo*, 1920 miles from *London*, to the ſouth-eaſt. I am ſorry to tell you, that I do not find theſe people deſerve ſo good a character as their anceſtors; they being now reckon'd very cunning, cruel and luxurious; and far from being famous for their courage.

Barbary.

The *Moors* of all this country, call'd *Barbary*, have no better character than the preſent *Egyptians*, being reckoned covetous, unhoſpitable, intent upon nothing but heaping up riches; and yet they are obſerv'd to be lively and ſharp wits, very dutiful and obedient to their parents, their princes, and their ſuperiors; and recommended for their reverence to God and Religion, and whatever is

eſteem-

Geography.

eſteem'd ſacred amongſt them: They will not ſuffer theſe to be burleſqued and made a jeſt of by profane fools, which is too often conniv'd at amongſt Chriſtians, and ſometimes encourag'd by thoſe who ought to ſet a better example. The *Arabs*, amongſt theſe people, have always had the character of a thieviſh pilfering generation, and perpetually led a rambling life: But thoſe, who inhabit the mountains, and have had the leaſt to do with the courts, or trade, are much the plaineſt and honeſteſt people. The moſt wretched, and abandon'd people here, are the *Renegadoes*, who have renounced Chriſtianity, and turned *Mahometans*; theſe prove the moſt vicious, treacherous mortals, that the country affords.——Theſe countries are *Biledulgerid*, *Zaara*, *Negroland*, and *Guinea*; but I find very little ſaid as to the character of the natives, only that thoſe of *Guinea* do not want ſenſe, but employ it to the vileſt purpoſes, in defrauding one another and the *Europeans* that deal with them. But it is thought theſe *Europeans* have, in great meaſure, contributed to make them thoſe exquiſite cheats. There is ſtill a more abandon'd race in *Guinea* than the Negroes; theſe are the *Mulattoes*, or mix'd blood, proceeding from the *Negroes* and *Europeans*, but exceed both in their vices. They are all eſteem'd ſuch maſters of their temper, and ſo eaſy in all conditions of life, that no ſudden changes or alterations in their fortune ſeem to diſturb them.

Ethiopia.

All this vaſt country, which I deſcribe with my finger, I ſhall call by the name of *Ethiopia*. The *Abiſſinians* here are ſaid to have a great deal of vivacity and natural wit; to be of a teachable diſpoſition, and fond of learning, tho' they have but few opportunities of improving themſelves. The *Hottentots* here are the lazieſt Generation under the Sun: They will rather ſtarve, or eat dried ſkins, or ſhoe-ſoles, at home, than hunt for their food; and yet when they do apply themſelves to the chace, or any other exerciſe, no people are more active, and more generous and hoſpitable; they will ſcarce ever eat a piece of Veniſon, or a diſh of Fiſh, or drink their beloved drams, alone; but call in their neighbours to partake with them, as far as it will go: Nor is this generous temper confin'd to their own countrymen, for they endeavour to ſhew their hoſpitality to the *Europe-*

Geography.

ans, whom they ſerve with the greateſt fidelity and application, when they contract to ſerve them for wages. We have little or no account of the other parts of *Ethiopia*, as ſcarce any traveller has penetrated into the heart of the country.

The African Iſles.

The Iſlands that I am now pointing out are call'd the *African* Iſles. The inhabitants of *Madagaſcar*, here, are reported to be a very indifferent ſort of people. The people of this Iſland, St *Helena*, are the honeſteſt, the moſt inoffenſive, and the moſt hoſpitable people, to be met with in foreign parts, of *Engliſh* extraction; having ſcarce any tincture of avarice or ambition: They retain the old *Engliſh* hoſpitality and ſincerity, the unaffected ſimplicity and benevolence, for which our country is remarkable.

British Empire in America.

Let us now croſs the vaſt ocean, and make a viſit to the *Britiſh* Empire in *America* here: This is *Carolina*, whoſe chief town is *Charles-Town*, 3450 miles weſt of *London*. The Indians here are a good-natur'd, generous people, very humane to ſtrangers; patient in want and pain, not eaſily provok'd, very quick of apprehenſion, gay of temper, and men of genius and natural eloquence.

The natives of *Virginia* were found, by the *Engliſh*, upon their firſt going amongſt them, to be moſt gentle, loving and faithful; void of all guile and treachery, quick of apprehenſion, and very ingenious; ſome bold, ſome timorous, but all of them cautious and circumſpect. The chief town of *Virginia* is *James-Town*, 3210 miles weſt of *London*.

This town, *Baltimore*, is the chief of the province of *Maryland*, ſituated 3000 miles to the weſt of *London*: The natives of this country are allow'd to be men of quick and ſprightly parts; they are active, and indefatigable in their warlike expeditions, hunting, and journeys: When any of them are condemn'd to death, they die like heroes, braving the moſt exquiſite torments, and ſinging even upon the rack.

Philadelphia, here, 3100 miles weſt of *London*, is the chief town of *Penſylvania*, whoſe Indians excel in liberality; nothing is too good for their friend; they are light of heart, and have ſtrong affections: The people in general are ſaid to be perſons of fine natural ſagacity; for a man will deſerve the name of Wiſe that outwits them in any treaty about a thing they underſtand. The character of the Indians on the reſt of the Continent, belonging to *Great Britain*, is pretty much the ſame. I need not tell you, that the *Engliſh* in theſe parts, do, in general, as far as I can learn, in their behaviour, keep up the deſerved good character of their countrymen in *Great Britain*.

Spaniſh Empire in America.

Theſe are the provinces of the *Spaniſh* Empire in *America*. The Indians of *Mexico*, here, when the *Spaniards* went firſt amongſt them, were a wonderful ingenious, inoffenſive, and hoſpitable people: They did not ſeem to have been defective, either in point of temperance, fortitude, or military ſkill: Both their policy and ſtratagems were exquiſite. They are admir'd by travellers for the mutual love and kindneſs that reigns in their families. *Mexico*, the capital city, is about 4800 miles ſouth weſt of *London*. The *Californians*, here, have a great deal of vivacity, and are naturally addicted to raillery; as the *Spaniſh* Miſſionaries found, when they began firſt to inſtruct them; for if they committed any error in their language, they jeſted and made ſport with the reverend fathers; and if at any time they explain'd any point of religion or morality, not conformable to the opinion of the *Californians*, they would wait for the preacher after ſermon, and diſpute with him, with a great deal of force and wit: If the Miſſionaries could give them good reaſons for what they advanc'd, they would ſubmit and act accordingly.

The Indians of *Terra Firma*, here, when the *Spaniards* firſt went among them, were a very good ſort of people: The chief town of this province is *Carthagena*, 4320 miles ſouth-weſt from *London*.

This city, *Lima*, 5700 miles ſouth-weſt of *London*, is the capital of *Peru*; but from the accounts we have

Geography.

lately receiv'd, the greateſt part, if not the whole city is deſtroy'd by an Earthquake, and the inhabitants ſwallow'd up. The natives of *Peru*, when the *Spaniards* firſt diſcover'd them, exceeded moſt Nations in the World, in quickneſs of wit and ſtrength of judgment: They are alſo extremely courteous in converſation, and friendly to ſtrangers: They had attain'd to a great degree of perfection in Morality; for their laws, cuſtoms, and doctrine of good manners, were their daily ſtudy, leſſons and buſineſs.

This is St *Jago*, the capital of *Chili*, 5700 miles ſouth-weſt of *London*. The *Chiliſians* are called the braveſt people in the new World, and are remarkable for their wit, patience and fortitude.

The Indians in this country, *Paragua*, are a brave people, and are become ſuch excellent mechanics, that they make Organs, and other muſical inſtruments, as well as thoſe that are carried from *Europe*: Others are Watchmakers, Painters, and Muſicians. The chief town in *Paragua* is *Aſſumption*, 5460 miles ſouth-weſt of *London*. The natives, call'd *Amazons*, are generally acknowledg'd to have as much humanity as any people, and a genius for painting and ſome mechanic arts.

Portugueſe Settlements in America.

This country is the *Portugueſe* Empire in *America*, call'd *Braſil*, and its chief city St *Salvador*, 4260 miles ſouth-weſt of *London*. The Indians are a kind, tractable, and ingenious people; ready to learn any art or ſcience of the *Portugueſe*; and take nothing ſo kindly of the reverend fathers as the inſtructing their children.

French;

This is the *French* Empire in *America*, and this *Fort Louis*, the capital, 4080 miles weſt of *London*. As theſe provinces reſemble, nearly, in character, thoſe which lie contiguous, I ſhall not repeat them here, but refer to the character of the inhabitants of *Carolina*, &c. The chief provinces belonging to the *French* are *Louiſiana*, *New France*, and theſe Iſlands ſcatter'd up and down.

And Dutch.

The dominions of the *Dutch* in *America*, are *Surinam*,

nam, here, in *Guinea*; *Curaſſow*, *Bonair*, and *Oraba*, here, near *Terra-Firma*. Geography.

This is *Weſt Greenland*, which the King of *Denmark* lays claim to; but it is an inhoſpitable country, upon account of the mountains of Ice and Snow. The *Greenlanders* do not want courage; they abhor theft, murder, and cruelty, and talk much of the immortality of the ſoul; and the Sun is ſuppos'd to be the ſupreme object of their worſhip. This is *Eaſt Greenland*, a country ſo cold that no mortals, that we know of, are able to live there. Weſt Greenland.

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CHAP. II. ASTRONOMY.

HAving thus taken a tranſient ſurvey of the internal and external parts of the Earth; the very Order of Nature itſelf dictates, that the Heavens, and the Relations which the ſeveral parts of the Univerſe have to our Wants, ſhould be the matter of our following diſcourſe. Aſtronomy.

The poor, illiterate, upright Man, who, without having made any re-ſearches into the particular Structure of the univerſal Syſtem, ſees enough to lead him to pay his conſtant adorations and thanks to that great and good Being, who created and ſuſtains this wonderful machine for his uſe, and continues to ſhower down daily his gifts and bleſſings on mankind: Both Reaſon and Religion conſpire to engage our attention to the language of the Heavens, of the Earth, and of the whole Univerſe, which with one common voice proclaim the glory of God, from one end of the creation to the other; they point out to us his inviſible perfections in the viſible operations of his hands. But if theſe conſiderations fail to lead you to the knowledge of Him who is the

Aſtronomy.

the great Author of them, and what he requires at your hands, you will ſtand convicted of a moſt criminal inattention, and unpardonable ingratitude. He diſcovers himſelf to us when we contemplate the various uſes of his works, in order to engage our affections in the moſt endearing methods of infinite bounty. —I ſhall now purſue what I have promis'd, in taking a proſpect of the other works of Nature, and ſhall endeavour to direct your thoughts to the great end, for which the Beauty, Order, and Riches, which adorn the whole circle of the Creation, were appointed. The Science which we are now enter'd upon is undeniably, of all Sciences, that which moſt elevates and warms the ſoul of man, by the grandeur of the objects it offers to our conſideration. It may properly be ſaid to enlarge his mind, in ſubmitting the very courſe of the Heavenly Bodies to his underſtanding; and to join, with the merit of doing mankind many ſignal ſervices, that of affording Piety motives both of a lively gratitude, and of the moſt profound veneration.

I ſuppoſe you were all pretty well ſatisfied about the figure of the Earth; but pray what do you think concerning the figures of the other viſible bodies in the Univerſe, the Sun, Moon, and Stars? If this Globe before us were ſuſpended at a conſiderable diſtance, it would appear flat and circular; the greatneſs of its diſtance makes the convexity imperceptible; and ſince a ſpherical body makes this appearance at a great diſtance, what figure, would the Earth appear of to a ſpectator remov'd from it to the great diſtance of the Moon? It certainly muſt be plain and circular, juſt as the Moon at full appears to us. —— Suppoſing then the Sun and Moon are vaſt ſpherical bodies, like this our Earth, and that they are placed at a great diſtance from us, they muſt alſo appear flat and round, and not ſpherical; and ſince they do appear ſo, they are undoubtedly ſpherical bodies. But this is confirm'd by ſome of the celeſtial bodies turning conſtantly round their Axis, juſt as I turn this little Globe round, and thereby they diſcover ſucceſſively to us all their different ſides; and ſince in every poſition they appear round, their figure muſt be ſpherical.

Aſtronomy.

You would, perhaps, be glad to know the reaſon that none of the other celeſtial bodies appear ſo large as the Sun or the Moon? You know that an artificial Globe, an hundred times larger than this before us, at ten miles diſtance could hardly be ſeen, or at beſt appear very ſmall; and from thence you may imagine that the Sun is much larger, as he appears the ſame 1000 miles off as here: If the Sun were remov'd to a greater diſtance from us, or, which comes to the ſame thing, we carried away with our Earth to a greater diſtance from him, he would ſtill appear leſs and leſs; and if the diſtance be properly increaſed, he would in time appear only like one of the biggeſt Stars, and afterwards like one of the ſmaller, and at laſt we ſhould loſe ſight of him altogether. It is quite inconceivable, at what immenſe diſtances ſome of the *Shining Bodies* in the Sky are placed from us; which will be of great uſe to you to remember, that you may upon occaſion call them to mind. When you conſider the diſtance betwixt us and the Antipodes, is little leſs than eight thouſand miles, it may ſeem wonderful to you, that ſuch a vaſt Globe ſhould be ſuſpended in the ambient ſpace of the Univerſe! And how muſt it heighten your ſurprize, when you take a ſurvey of the multitude of vaſt Globes continually rolling over our heads! The Moon performs her courſe, at the diſtance of about 240,000 miles from the Earth. A ſpectator placed in the Moon, looking towards the Earth, would obſerve it in the Heavens, and the face of it would appear fifteen times bigger than the face of the Moon does here. The Moon is placed at ſo little a diſtance from us, (compar'd to the diſtance of the other celeſtial bodies) that it alone throws a greater quantity of Light upon us, than all the Stars together, tho' theſe be as many Suns. The Creator has remov'd the Stars ſo very far from us, or keeps us ſo far from them, that the Night we ſtand in need of cannot be impair'd by their brightneſs; and he has ſituated the Moon ſo near us, that it becomes a magnificent glaſs, which returns to us in the Night a great part of the Light of the Sun. This faithful Satellite offers to all Nations of the Earth a watch-light, which takes every ſeven Days a form entirely new. The *Hebrews,*

Greeks,

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Greeks, the *Romans*, and all the Ancients in general, uſed to aſſemble at the time of the new Moon, to diſcharge the duties of piety and gratitude, for the manifold uſes of this heavenly body; which it will never fail to afford us, till He, who for our ſake has appointed them, ſhall think fit to change its functions with the ſtate of man.

We find the characters and marks of an expreſs Will, full of tenderneſs towards us, in all the numberleſs bleſſings, which God multiplies from Year to Year and from Day to Day, both upon and within the Earth. But with what ſplendour and magnificence does that Will ſhew itſelf in the beauty of the Sun, and in the juſt proportion of ſize, diſtance, action and uſefulneſs, that has been eſtabliſh'd between that and the Earth!

As large as the Globe of our Earth is, the Sun's glorious body is almoſt a million of times bigger. Let us ſuppoſe the diſtance from the artificial Earth and my foot to be 240,000 miles, as I told you before; and if you draw a circle with chaulk round that Globe, the ſpace contain'd in that circle, is call'd the Moon's Orbit. Now if you imagine the Sun placed where the real Earth now is in the Heavens, it would fill the whole Orbit of the Moon, and reach to this circle which I am now drawing, and which is about half as far again as the diſtance of the Earth from the Moon, that is, to the diſtance of near 360,000 miles. Prodigious! It is not therefore without reaſon, that we call this glorious body a vaſt Ocean of Heat and Light. What a ſmall thing is our Earth, in compariſon of the Sun; how is it ſhrunk up! You now no longer wonder, that the Sun ſhould appear equally big over the whole Face of the Earth; for this is only to appear equally big over the whole ſurface of a Point. Nor is the reaſon hard to be found out, why he ſhould be ſuch a vaſt body, as its Heat and Light were to be diffuſed through the whole ſyſtem of wandering Globes, that ſtand in conſtant need of his enlivening rays and aſſiſtance. In the whole immenſity of the Heavens, this glorious body alone, when he appears, ſtrikes our eyes, and overſpreads nature with ſplendour and glory; but during his abſence we perceive

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an innumerable multitude of Fires on every ſide; and yet this ſingle flambeau, when he aſcends the Heavens with a majeſtick ſtate, makes us amends for the loſs of the other lights, drowning them all by the ſuperiority of its own. We ſhall be amazed at the thoughts of what the moſt learned and moſt exact Aſtronomers ſay concerning the diſtance of the Sun from us. They tell us, that we are near ten thouſand diameters of the Earth from it; that is, near 80,000,000 miles. But if we confine ourſelves to the half product of their calculations, notwithſtanding the exactneſs and regularity which nobody will refuſe to aſcribe to theſe great men, of courſe I ſhall not be ſuſpected of any intention here to augment the marvellous. To make you more ſenſible, what a prodigious ſpace that half ſtill is, let us take poſt and ſtart from the Earth, in order to get to the Sun, and travel at the rate of one hundred miles a day, without faintneſs or interruption: When we have travell'd 1095 Years we ſhall ſtill be ſhort of our journey; and if that time be not ſufficient to arrive at the Sun, according to our calculation, which falls ſo very ſhort, nay, which is not even half of what is demonſtrably known and matter of fact, at what period of time would you arrive were the juſt diſtance known, which neither our Eyes, or any of our Inſtruments, are able to take in? What then can be that Globe, which alone cauſes a general Renewal at the very inſtant of its appearance? Is it a Globe wholly compos'd of Fire? How can it operate ſo powerfully and at ſo vaſt a diſtance? How comes it, during the ſix thouſand ſucceſſive Years it has lighted and heated Nature, not to have loſt the greateſt part of its ſubſtance, by the conſtant Effluvia of it emitted therefrom? You may perhaps hereafter have the moſt plauſible Anſwers that can be made to theſe Queries: — God hides from us nothing but what is uſeleſs or dangerous.

I ſhall now ſhew you all, in few words, the true conſtitution of what is called the Solar, or planetary Syſtem, by this ſcheme before us, which will make the thing more intelligible than words can do, as the Imagination is beſt inform'd from the Eyes. In the center of the whole Syſtem is the Sun himſelf, which, notwithſtand-

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ing the diminutive appearance he makes to us at this diſtance, is an immenſe Ocean of Heat and Light, as was ſaid before. In this vaſt ſpace of the Heavens there are ſix Globes, call'd the Planets, that perform their courſe round the Sun. The next to him is the Planet call'd *Mercury*, which performs a revolution round him in about three Months time. This Globe, next to *Mercury*, is call'd *Venus*, which makes a fine appearance in the Heavens, ſeeming to dart a ſtrong and beautiful Light; ſhe finiſhes her journey in about ſeven Months and a half. Next to *Venus* is our *Earth*, which compleats its courſe round the Sun in the ſpace of a Year. Next to the *Earth* is *Mars*, being the fourth in order from the Sun, and takes up near two Years in moving round him; for the motion of the upper Planets becomes always ſlower. At a great diſtance above *Mars* is *Jupiter*, the ſtatelieſt and moſt majeſtick of the Planets; this Globe requires little leſs than twelve Years to compleat his period round the Sun. Laſt of all comes *Saturn*, and cloſes up the planetary Chorus; for his Orbit ſurrounds them all. As he is the remoteſt from the Sun, he cloſes the Syſtem with State and Dignity, having a miraculous ſort of an Arch or Ring about him. *Jupiter* and *Saturn* have Moons, not unlike ours, which continually accompany them. While the Earth performs her Revolution round the Sun, our Moon, as an attendant, revolves about the Earth between twelve and thirteen times. *Jupiter* has four Moons rolling about him, one with another, and afford a delightful ſpectacle, and conſtant variety of appearances to a ſpectator there. Without the Arch of *Saturn* are five Moons, which attend him through his whole courſe, as the Moon does our Earth; the motion of *Saturn* being the ſloweſt of all, before he can finiſh his tedious journey round the common centre of the Planets, it is twenty-nine Years and near an half. The proportion of the diſtances of theſe Heavenly Bodies, from the Sun, are nearly the ſame repreſented in the ſcheme before us: That is, ſuppoſing the diſtance of the Earth from the Sun to be divided into ten equal parts, of theſe the diſtance of *Mercury* will be four, of *Venus* ſeven, of *Mars* fifteen, of *Jupiter* fifty-two, and that of *Saturn* ninety-five. As we before found an amazing diſtance between the Sun and the Earth,

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we are here again ſurpriz'd with the diſtance between the Planet *Saturn* and the Earth! Theſe ſeventeen Globes are but a ſmall part of thoſe Lights we obſerve in the Heavens: For beyond the limits of our planetary World, and at an immenſe diſtance without the Orbit of *Saturn*, are the Globes we call Fix'd Stars, which you ſee ſparkling in a Winter Evening, with ſuch various ſplendour and magnitudes. The reſt of the Heavenly Regions beyond *Saturn*, are to be conceived as divided into ſpaces juſt like that I have been deſcribing, each having one of thoſe Heavenly Bodies in its centre, which are call'd Fix'd Stars, performing the office of a Sun to it, and having, it may be, Planets of its own revolving about it. —— Beſides the abovemention'd Planets moving round our Sun, there are likewiſe wandering Globes call'd Comets; and theſe ſhew themſelves only when they are in thoſe parts of their tedious journey that are neareſt us and the Sun. Some of theſe Comets, which thus revolve about the Sun, are ſuppoſed to take not many fewer than ſix hundred Years to perform their circuit. This is aſtoniſhing! Such a Body muſt go to an incredible diſtance, and have made but very few viſits down to the centre of the Syſtem ſince the World began! There is one of theſe Comets whoſe journey is reckon'd to be 575 Years, and goes above fourteen times the diſtance of *Saturn* from the Sun; which is an amazing Heighth, if we conſider it in itſelf, and not as it is expreſs'd in this ſmall number. This ſcheme before me will deſcribe the path of a Comet, ſo as to give you a tolerable idea of it. How various and wonderful are the Works of God! This is a new and tremendous ſcene! How dreadful is the power of that Almighty Arm, which ſo projects theſe unknown bodies that they paſs without the limits of our World; with ſuch meaſur'd force, that they return from thence, inſtead of flying off to other Regions of the Univerſe; with ſuch direction and Skill, that they do not daſh againſt the Planets, and bear down the Globes of our Syſtem! I know the ſubject excites in you becoming ſentiments of reverence; and I ſhall not be ſurpriz'd, if you in your future lives act contrary to the ſtupid vogue among Youth of fortune, of neglecting the contemplation of theſe noble Truths; and of giving themſelves up to diverſions, drinking,

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gaming, and the train of Evils uſually conſequent thereon. You perhaps will ſay, what is the uſe and deſign of thoſe wonderful bodies, the Comets, which move thus through the Syſtem in a manner peculiar to themſelves? Are they habitable? Why do they approach ſo near the Sun as this ſcheme before us expreſſes? And then run out to ſuch an unmeaſurable diſtance from him? Can there be ſuch bodies in other Syſtems? Or is ours ſingular? We ought humbly to adore and reverence a Knowlege ſo infinitely ſuperior to our own, even in theſe wandering Globes, the uſe of which we are quite ignorant of; nor are we to imagine that we can diſcover all the reaſons why a thouſand things in the Univerſe are ordered ſo.

Our Earth performs the ſame ſervice to our Moon, as the Moon does to it; or rather, a great deal more; ſince it reflects upon her above fifteen times a greater Light than it receives from her. You may conſider what effect the Moon-light would have, if it became fifteen or ſixteen times brighter; for if you can read a ſmall print by our Moon-light, what might you do there? Fifteen times our Moon-light would make a kind of Day-light; and we might travel, and do all manner of buſineſs by it, as conveniently at leaſt as now in gloomy weather. The Earth muſt appear there by Night near ſixteen times larger than the body of the Sun himſelf; and therefore muſt throw a vaſt gleam upon a ſpectator by Night in thoſe parts; which muſt be a fine ſight to them, to have a Moon ſo large! Beſides, he would enjoy a pleaſant view of the converſion of the Earth round its own Axis in 24 Hours, juſt as I turn this Globe round. By means of this Rotation, he would be furniſh'd with a conſtant variety of objects on his Moon, offering themſelves to him ſucceſſively. Our Seas and Continents would be diſtinguiſh'd by different brightneſs of colour; the Seas, drinking up the rays, reflect but little Light; but the ſcorched plains of *Africa*, and all hot Countries that lie in theſe parts of the Earth here, where I point, muſt have a ſtrong ſplendour; whilſt ſome of the inland Seas, by their Darkneſs, muſt ſet off the luſtre of the neighbouring Continents.

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But if we go on to conſider the larger bodies, *Saturn* and *Jupiter*, they make ſtill an incomparably more glorious appearance to their Moons; each of them appearing ſome hundred times larger than the Sun does to us, and many thouſand times larger than the Sun appears to themſelves. *Jupiter*'s Disk is in reality a hundred times larger than that of our Earth; and the innermoſt of his Moons is not quite ſo far diſtant from him as our Moon is from us: Therefore he muſt appear to the innermoſt of his Moons a hundred times larger than the Earth does to our Moon. But the Earth appears to our Moon near ſixteen times larger than the Sun does to us; ſo that *Jupiter* appears to the innermoſt of his Satellites almoſt 1600 times larger than the Sun does to us. This would be an inconceivably new and glorious Sight in our parts of the Syſtem! Add to this, ſince the Sun's Disk appears twenty-five times leſs there than to us, *Jupiter* appears 40,000 times larger to the neareſt of his Satellites than the Sun himſelf.

I ſhall next ſhew you, what appearance *Saturn* makes to his Moons. *Saturn*'s Disk is about ſixty-four times larger than the Earth's; therefore he appears to two or three of his neareſt Satellites about ſixty-four times larger than the Earth does to our Moon; and conſequently upwards of 1000 times bigger than the Sun appears with us. The Sun's Disk there is near 100 times leſs than here. *Saturn* therefore, at the diſtance of our Moon, appears about 100,000 times bigger than the Sun himſelf does. Thus *Jupiter* and *Saturn* muſt appear to their Satellites, not as Moons but prodigious reſplendent Orbs in the Heavens, taking up no ſmall ſpace in the azure Firmament with their luminous bodies. For on allowing *Jupiter*'s Disk to appear 1600 times larger than the Sun's to a ſpectator on our Earth, you will find that his Diameter extends to one and twenty Degrees in the Heavens; or to make it plainer to you, twenty Degrees is about the ninth part of the archy Sky over our heads; ſo that nine ſuch bodies as *Jupiter* appears to his neareſt Satellite, muſt do more than reach from one ſide of the Heaven to the other. When this majeſtick Planet riſes to his Satellites, a whole quarter of the Firmament

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mament muſt ſeem in a blaze of Light. *Saturn* to the innermoſt of his Satellites appears of incredible bulk; bigger than *Jupiter* himſelf to the innermoſt of his, if it were worth the while to be particular in theſe things. But at the diſtance of our Moon from us, *Saturn*'s Diſk is about 10024 times larger than the Sun's to us; his Diameter at this diſtance is about ſeventeen Degrees, or ten and a half ſuch bodies as he, plac'd by each other's ſides, would extend over the whole Heaven, from Eaſt to Weſt. We ſaw before, that the Heaven of *Jupiter* and *Saturn* was beautiful and glorious, but this view of the Heaven of their Satellites ſurpaſſes the Force of Imagination; for we may add to this, that every Satellite enjoys a fine proſpect of its neighbouring Moons, which muſt appear to it as well as to their primary Planet. What do you think can be the uſe of this profuſion of Light, thrown on theſe ſecondary Planets, even by the Primaries themſelves; or of that Light reflected on our Moon by the Earth: It is certain, that a thing thus laid out with ſo much ſtudy, and executed by ſuch mighty contrivance, cannot be without deſign, and for no purpoſe. The Almighty Architect would never have made uſe of ſuch laborious methods as we have ſeen, to furniſh the moſt remote bodies of our Syſtem with ſuch variety of Light, if Light had not been abſolutely neceſſary to them. Our Moon illuminates the darkned part of the Earth in the Sun's abſence, and the Terraqueous Globe itſelf would not ſtand in need of Light, if it were not inhabited. I mean by this, that all the other planets, as well as our Earth, are habitable Globes, and the reſidence of ſuch to whom the Light of the Sun may be ſerviceable; or, to ſpeak more juſtly, to whom it is altogether neceſſary. Why was a Sun neceſſary at all in the Syſtem, if not upon this account? Why might it not have been dark, a torpid, and a motionleſs Abyſs? Or why was the frame of Nature built at all? The Syſtem requir'd a Sun, regular motions, and the preſent contrivance, becauſe it was to be inhabited. Call to mind the Heavens of *Jupiter* and *Saturn*, what bright parts of the Univerſe thoſe are; and if we ſuppoſe a ſpectator brought from thence to our Regions, he muſt think he were convey'd to a dull and languiſhing part of Nature. If we compare the Works of the Creator among themſelves

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ſelves, the contrivances for illuminating the ſuperior Planets, are, without controverſy, extremely more ſtudied than in the lower parts of the Syſtem. Was it to have a Sun and theſe contrivances, that only a hundredth part of it, nay, that leſs than the hundredth part of it ſhould be inhabited? Was it to have theſe contrivances that it might be uninhabited even where they ſeem to have been moſt ſtudied. The whole Syſtem is ſuch an expreſſive Artifice, as is not eaſy to be miſtaken: Otherwiſe what Difference would there have been, whether the Planets had been plac'd far from, or near the Sun, were they not to have been repleniſh'd with inhabitants, who might perceive the advantage of the Light? Or what needleſs work had it been, ſo carefully to provide the comforts of living Beings for things void of life? The Sun was to cheriſh them by his Heat and Light. To cheriſh what? Some mighty Globes of dead matter! No reaſon at all would be better than this. Every thing confirms what I would advance to you, and nothing, ſo far as I know, makes againſt it. For why ſhould our Earth alone of all the Planets be furniſh'd with inhabitants, ſince it is neither the greateſt, nor the innermoſt, nor the outermoſt, nor the beſt furniſh'd with Light, or with variety of it, to receive them: I ſay, why ſhould it of all the Planets be graced with inhabitants, while others, either larger or nearer the ſource of Heat and Light, are left empty and deſolate? It vaniſhes long before we come to *Jupiter* or *Saturn*, the leaſt of whoſe Satellites are probably as large. Could not this Earth have rolled round the Sun, and been inhabited, unleſs it had been attended with thoſe larger Bodies, rolling likewiſe round about him at ſuch prodigious diſtances, without inhabitants? There ſeems to be no medium, between remaining quite ignorant of all the miracles of power and wiſdom, which appear in the Heavens, and coming into this notion: And on this account it was, that men came into it, as ſoon as they began to compare this Earth with the other great bodies in Nature, and found that it was but as a Point in compariſon of the Univerſe. Since there is ſo little doubt of the primary Planets being habitable, what do you think muſt be the uſe of that great Light reflected on the Moon by our Earth; or by that profuſion of Light reflected by thoſe larger bodies, *Jupiter* and *Saturn*, on their Secondaries? Theſe ſecondary Planets certainly anſwer a more noble end, if they are the ſeats of living Beings, than if they only reflected the Light emptily on other empty Globes. Without this we cannot imagine to what purpoſe theſe Spheres ſhould reflect the Sun's ſplendour from one to another, and keep up an eternal dance, unperceiv'd by any creatures, unleſs perhaps by a few ſtudious perſons here on Earth, peeping through a Teleſcope. We muſt not think that ſuch wonderful ſights ſhould have been ſo far removed from us, if there were none elſe to admire them; the thought is ſhocking. It is of conſequence in this affair to conſider, that on the ſurface of the Moon, by the aſſiſtance of a Teleſcope, are diſcover'd Mountains, Rocks, Lakes, and Seas; all which ſhew a Planet not unfit for habitation, but diſpoſed like our Earth.—Now pray what may your thoughts be of that ſingular piece of divine workmanſhip, the ſtupendous arch mention'd before, which ſurrounds the body of *Saturn?* It ſeems not wholly deſign'd for reflecting the Light on the interior Planet; ſince it keeps off as much at one ſeaſon as it reflects at another. There is no abſurdity in ſuppoſing this pendulous ſtructure may be habitable, and ſerve at the ſame time for ſome great purpoſe to the Planet it ſurrounds, as well as receive advantage from it. But the ſafer way is to own, that it demands our admiration, while it is beyond our reach to diſcover the uſe for which it was thus contriv'd. The Planets, both primary and ſecondary, could not have been made on the account of brute Animals, which can neither conceive the beauty of the work, nor acknowledge the benevolence of the Creator, nor have their Nature improv'd by the power and wiſdom diſplay'd in the order and variety of the parts. Undoubtedly a nobler gueſt was to be placed in thoſe magnificent Globes, who, tho' perhaps not reſembling us in all particulars, may nevertheleſs be endu'd with the ſame rational nature, and that poſſibly in greater perfection, in proportion to the dignity of thoſe nobler Manſions. The fixed Stars may have each their Syſtem of Planets, which cannot be diſcerned by us at this immenſe diſtance; and they may ſhine to the inhabitants of thoſe Regions. For can we imagine that they ſhine for the

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ſake of thoſe who do not perceive the hundredth part of them, without the help of a Teleſcope, or even perhaps with the aſſiſtance of that Invention? The Inhabitants of thoſe immenſely remote parts and we ſeem to be much in the ſame condition. To a ſpectator placed there our Sun muſt appear as a Fixed Star, and our ſolar Planets be quite abſorbed, by the immenſity of the diſtance: Yet it would not follow, that there was no ſuch thing as our Earth, and that no living Being exiſted near that Fixed Star, as he would call it. How vain is Man, who makes himſelf the only favourite of Heaven, and claims to himſelf alone the care of Omnipotence! As if the kindneſs ſhewn him ſuppoſed a neglect of all other things; or as if he were injur'd, unleſs the Univerſe were an infinite Waſte to pleaſe him. Modeſty requires us to acknowledge, that the other bodies in the Univerſe may have their Inhabitants, who may be equally dignify'd by Reaſon with ourſelves! You may for the future contemplate the face of the Heavens, in the Night time, with more delight, while you conſider that all, above you, are not ſo many bright ſtuds with which the vaulted roof of Heaven is adorned, or that it is not a wild ſolitude, deſign'd only to fatigue the eye, diſtreſs the imagination, or amuſe puny mortals; but that Rational Beings inhabit thoſe Regions, and admire with us the wiſdom of the common Creator, diſplay'd in their different views of Nature.——The outermoſt and innermoſt of the Planets may not be uninhabitable by reaſon of the extremities of Cold and Heat; that is not always in proportion to our vicinity to the Sun; and Cold requires a poſitive cauſe, or ſomething more than the meer abſence of Heat: The extremities of both may be qualify'd by the conſtitution of an Atmoſphere, with which all the Planets are ſurrounded. Tho' *Saturn* has but about a hundredth part of the Sun's Heat which we feel, yet we are not ſure that the hundredth part of our Heat will amount to any degree of poſitive and real Cold, without the Co-efficiency of ſome other poſitive and real cauſe. It is not difficult to conceive, that the conſtitution of his Atmoſphere may be ſuch, as to make that Planet a mild and temperate Clime. And if there be any weight in this, it will not be hard to apply it to the inferior Planets, *Mercury*

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and *Venus* ; for we ſometimes feel the Heat of our Summer as much qualify'd by ſome different cauſe, as the Rigour of our Winter. So that Heat and Cold may not abſolutely depend on a Planet's nearneſs to, or diſtance from the Sun, but, together with theſe, on ſome other cauſes.

I come now to ſhew you, that the great Changes in Nature, with reſpect to us, are owing to the diurnal and annual motions of the Earth ; inſtead of the Heavens and whole frame of Nature whirling round in twenty-four hours : That inſtead of this monſtrous converſion, the Earth only performs a revolution on its own Axis in the ſame time : That the viciſſitudes of the Seaſons, and lengthening or ſhortening of the Days and Nights are caus'd by the motion of the Earth round the Sun in the Space of a Year. You ſee here that this room does not wheel round the Globe before us, but I twirl the Globe about with my fingers, while the room remains immoveable. What paſſes in the Heavens is not different from this repreſentation of the matter, which I have given you. You ſee plainly the Heavens have been carried from Eaſt to Weſt, while the Earth, you think, ſtands ſtill ; but here on the contrary, the room has no motion, only I turn this Globe. You do not perceive the Heavens to move more than the Earth, nor the Earth to reſt more than the Heavens : Only after ſome time, you ſee that the part of the Earth where you are, hath changed its ſituation with reſpect to the Heavenly Bodies. Wherefore your Senſe does not ſhew you either the motion of the Heavens, or the reſt of the Earth, which you ſtand upon ; and you perhaps have wonder'd how the Sun moves over ſo large a ſpace every day, and yet ſeems not to ſtir out of the place. The Truth is, you do not ſee the motion of the Sun or Heavens, but infer from having chang'd ſituation, with reſpect to them, that they move and the Earth ſtands ſtill. From hence it would be as agreeable to reaſon to infer from the change of ſituation, between the parts of the Earth and the Heavenly Bodies, that the Earth moves and the Heavens ſtand ſtill. Where the informations of our Senſes are doubtful, we ought to conſider the reaſon of things, and determine according to them. Let us ſup-

poſe,

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poſe, that the Earth really moves round from Weſt to Eaſt, juſt in the ſame manner as I turn this Globe of the Earth before us, and let us ſee what changes would happen. On the Eaſt, ſome parts of the Heavens would always be riſing, and on the Weſt others always be ſetting; and in twenty-four hours, the whole Heavens would thus ſeem to riſe and ſet. Theſe are the appearances we ſhould obſerve on this Suppoſition. You may perceive now from what has been ſaid, that it is the ſame thing, as if the Earth ſtanding ſtill, one of you were carried in twenty-four hours, from Weſt to Eaſt quite round the Earth, you muſt ſee the Heavens and Stars thus to riſe up before, and ſink down behind you: You may plainly ſee, that the Earth's carrying you from Weſt to Eaſt, or you moving over the (immoveable) Earth, in the ſpace of twenty-four hours, and to the ſame part of the Heavens, could not alter the appearances of the Celeſtial Bodies, ſeeming to riſe as yon advance to the one ſide, and ſet as you retire from the other. You will eaſily perceive from thence, that we could be ſenſible of its motion no otherwiſe, than by obſerving the Horizon, as it is call'd, where the Sky and Earth ſeem to touch each other, on the Eaſt and Weſt points; for all the changes produc'd by this motion muſt appear there. Thus then all the changes wonld appear the ſame, if the Earth moved and the Heavens ſtood ſtill. A perſon could not be ſenſible of motion, unleſs he perceiv'd himſelf to draw nearer ſome objects, or leave others far behind him. If we ſuppoſe that the Earth mov'd ſo ſwift round its Axis, that our Iſland would return to the Sun (by ſuppoſition immoveable) every quarter of an hour; in that caſe, what motions do you think ſhould we perceive? We could then no more perceive the motion of the Earth than at preſent; but the Sun and Stars would ſeem to roll over our heads, with the ſwiftneſs of a bird flying. In which caſe indeed, even our ſenſes would ſeem to inform us of the motion of the Heavenly Bodies. Our ſenſes inform us, that the Moon moves to the North, with the ſame celerity that the Clouds below her fly towards the South: They inform us, that the trees, houſes, and other objects on ſhore, draw back from the ſhip in which we are, while ſhe goes out of the harbour. —— I now proceed to give

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the reaſons why the Earth ſhould move rather than the Heavens. *Jupiter*, the largeſt of the Planets, and far ſurpaſſing the Earth in magnitude, is obſerv'd to roll round on his Axis in about ten hours: *Mars* performs a revolution on his Axis in the ſame time nearly as our Earth; and *Venus* in about twenty-three days: Tho' *Saturn*'s great diſtance from us, and *Mercury*'s being too near the Sun, has hitherto hinder'd the ſame obſervations to be made upon them. It is perfectly agreeable that the Earth, which is itſelf one of the Planets, ſhould have the ſame motion as the reſt of them have. Beſides, *Jupiter*'s rolling round on his Axis, in ten hours, would make the whole Heavens to appear to them to turn round in that ſhort time, juſt as they ſeem to us to turn round in twenty-four hours; though it is plainly impoſſible, that one and the ſame revolution ſhould be perform'd in twenty-four hours and in leſs than half that time. In ſhort, if all the Planets turn round on their Axis in different times, the Celeſtial Bodies, tho' unmov'd, would ſeem to a ſpectator, plac'd on theſe Planets, to revolve in as many different times. Nay, if any great Globe rolled on its Axis from Eaſt to Weſt, while others really turn from Weſt to Eaſt, the Sun and Stars, to the different ſpectators, would appear to turn from Weſt to Eaſt, and the contrary way, at one and the ſame time. And why ſhould not the Earth, one of the ſmalleſt Planets, revolve on its own Axis in the ſpace of twenty-four hours, rather than that all the World, infinitely larger in bulk, ſhould be carried round in the ſame time with inconceivable rapidity, as being plac'd at an immenſe diſtance from it: And all this to no other purpoſe than to bring about the viciſſitude of Light and Darkneſs to this one little body, the Earth we live on! It receives no other benefit that we know of, from the whirling round of the whole Heavens, than the enjoying the viciſſitude of Light and Darkneſs every twenty-four Hours. And if the Sun alone could procure it this advantage, by his revolving about it every day; to what purpoſe is it to bring in ſo many amazingly great Globes to perform this effect, which do not contribute any thing towards it? It is certainly more reaſonable in every reſpect to acknowledge the rotation of the Earth round its own Axis, than to raiſe ſuch an infinity of motion through all Nature to no end.

You may perhaps, from what has been ſaid, be fully ſatisfied of the reality of the Earth's turning round itſelf in twenty-four hours, from Weſt to Eaſt; but yet you would be glad, as there are ſome objections, to have them anſwer'd. If you throw a ſtone directly up, you obſerve, that it falls down juſt at your feet again; but if the Earth whirl'd with ſuch rapidity from Weſt to Eaſt, the part from which the ſtone was thrown up, muſt be carried a conſiderable way eaſtward while the ſtone is in the air; ſo that it would fall to the weſt of the part from whence it was caſt up. A ſtone dropped from the top of a high tower would not fall juſt at the foot but to the Weſt of it: And birds, when they fly to the Eaſt, would be left behind towards the Weſt, or if they fly towards the Weſt would be forwarded; but on the contrary, they perform their flight, you obſerve, over an equal diſtance of the Earth, in an equal time, both ways indifferently; which could not be, if the Earth moves ſo ſwiftly below them. You have alſo obſerv'd, if you run with ſome violence, a breeze always meets you in the face, though there be no air ſtirring; but you think there ought conſtantly to be a ſtrong wind from the Eaſt, while the place we are in is carried from the Weſt to the Eaſt with ſuch force. In order to remove ſome of theſe difficulties, you muſt know, that a body, which is contain'd in a thing, partakes of the motion of that thing which contains it. If a Ship be under ſail, and move ſmoothly along, the ſeveral motions of the people below deck, or walking above, are perform'd in the ſame manner as if the Ship ſtood ſtill. It is obſervable, that Flies in a Ship continue their flight indifferently towards all parts, and are never driven together towards the ſide of the cabbin next the prow, as if wearied with following the ſwift motion of the Ship. This inſtance may ſerve to give you ſome ſort of an idea of the flight of birds, which partake of the motion of the Earth, even while they are in the air, in the ſame manner as the Flies do in the Ship: For the air partakes of the ſame motion with the Earth; ſo that birds fly up and down in it, as if the Earth or it had no ſuch motion. And ſince the air partakes of the ſame motion with the

Earth, there cannot be a conſtant breeze from the Eaſt, mention'd before, ſweeping over the plains. Nor by any reaſon of the Ship's motion, can a perſon make a longer leap towards the ſtern than the head, notwithſtanding that whilſt he is up in the air, the floor under his feet runs a contrary way to the leap. The ſmoke of incenſe will hang like a Cloud, moving indifferently, this way or that way, without any inclination to one ſide of the Ship more than the other. A bottle of water being hung up to empty itſelf, drop by drop, into another bottle placed beneath, with a narrow neck, the drops will all fall into the bottle, and not one towards the ſtern, tho' the Ship ſhall have run many inches whilſt the drop was in the air. It is indeed amazing, that our bodies ſhould be conſtantly hurried along with ſuch prodigious impetuoſity; and yet that we ſhould be as little incommoded by it, and even inſenſible of it, as if nothing ſtirred in Nature! The liquor in the cup is not ſhaken, the infant that has but juſt ſtrength to ſtand upright is not moleſted, and every thing is as ſtable and firm, as if our Earth reſted on ſome eternal foundation!

I come now to ſhew you that the viciſſitudes of the Seaſons, and lengthening or ſhortening of Days and Nights, are caus'd by the motion of the Earth round that vaſt Ocean of Heat and Light, the Sun. You cannot think it ſo proper, that the nobleſt body of the Syſtem ſhould revolve about the leaſt bodies in it; and that the fountain of heat and light to the whole Syſtem ſhould leave the centre, the moſt proper place for diſpenſing theſe equally, and go here and there, to chear one part of it while the other parts are left languiſhing and uncomfortable till his return. But there is an eaſy way of proving, that the Sun is the centre of the Syſtem, from the revolutions of *Venus* and *Mercury* about him; and beſides, there are other appearances in the motions of *Mars*, *Jupiter*, and *Saturn*, which confirm the ſame. There is ſtill a more noble argument, which illuſtrates and confirms the order and motions of the planets round the Sun, in a manner altogether particular, which is this: The times of the revolutions of the Planets round the Sun, and their diſtances from him, are connected by a certain proportion; but on the contrary, if we place the Earth in the centre of the Syſtem, ſuch a diſpoſition would ruin the moſt beautiful proportion, and ſtruggles againſt the ſtrongeſt neceſſity. All which I ſhall fully prove to you in a more proper place, when you are better prepar'd for theſe matters. The reaſon why people aſcribe to the Sun not only a diurnal, but alſo an annual motion round the Earth, is a miſtaking the apparent for the true motion. For while the Earth is carried round the Sun, the Sun ſeems to move the contrary way. This appearance they take to be a real motion in him; as if any one ſhould fancy a diſtant tower to move the contrary way to that which he himſelf was going, becauſe it ſucceſſively intercepted the view of more remote objects in a contrary order. And yet, at this rate, the Sun, beheld from different Planets, (*Jupiter* and our Earth for inſtance) would appear to move two contrary ways at once, as the Planets themſelves were carried to oppoſite ſides; which is abſolutely impoſſible. And not only two contrary ways at once, but (as was obſerv'd, with reſpect to the diurnal motion) he would ſeem to be carried round the Heavens in very different times. For a ſpectator, in any of the Planets, would fancy that Planet immoveable, and impute both its motion and periodical time to the Sun. Thus to a ſpectator in *Mercury*, he ſhould appear to be carried round in three months; and to another in *Saturn*, ſcarcely in thirty years: So that nothing ſolid can be eſtabliſhed on an appearance of ſuch an ambiguous and equivocal nature as this.

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You muſt remember that you cannot perceive the diurnal motion of the Earth with your eyes, but infer it from the changes which that produces: It is the ſame with regard to the annual motion of the Earth round the Sun; you can only know it from the changes which that produces. The deduction of this matter, I am afraid, will fatigue you: for you muſt attend to a variety of circumſtances at once, and yet ſcarce any thing is more neceſſary to be known, or more worth your attention. Some of theſe conſtellations on this Globe before us, which is a repreſentation of the Heavens, will help us to explain, how theſe changes are brought about by this motion of the Earth. This is the conſtellation *Pleiades*, this *Orion*, and this the *Greater Bear*; which will be ſufficient for our purpoſe. You muſt imagine this room to be form'd into a large hollow Globe, and that all theſe figures on this artificial celeſtial Globe be drawn on the concave part of the room, which then will repreſent the vaulted roof of Heaven. Let this Globe ſtand here in the centre and repreſent the Sun; this the Earth on which we are all now ſitting; this floor ſuppos'd to be taken away, ſo that none but thoſe two Globes are to be in the centre of this hollow room or ſphere, and all the Fix'd Stars ſhining at an immenſe diſtance round about both above and below us. This ſemicircle of thread which I am now fixing repreſents half the path of the Earth round the Sun, in the ſpace of a year. When the Earth, in its annual courſe, is got here between the Sun and the *Pleiades*, on this ſide, they become obſervable in the night time, as not being interrupted from our ſight by the Sun's rays. And in this manner they appear during the whole Winter; only they ſeem to get more Weſterly every night, as the Earth moves gradually by them to the Eaſt, in the ſame manner as I move this Globe to this part of the room. As the Spring approaches, the Earth by degrees withdraws itſelf from between the Sun and them, and moves to the oppoſite part of the Orbit: Whence it comes to paſs that the Sun, plac'd in the centre, ſeems to draw nearer the *Pleiades*, till at length, the Earth thus advancing in its courſe, the Sun gets between it and the Stars, which then lie hid behind its rays. And after the ſame manner, while the Earth performs its annual courſe, the Sun, which always ſeems to move the contrary way, darkens, by his uncontroulable ſplendour, the other Conſtellations ſucceſſively: But ſtill the Stars, oppoſite to thoſe thus intercepted, (between which and the Sun the Earth paſſes) become conſpicuous to the Earth from behind.

Thus beholding the Heavens in the night time, you may diſcover the relative motion between the Sun and Earth; which you may imagine without difficulty. The Stars muſt come in view ſucceſſively, on the part of the Earth turn'd from the Sun, that is, in the night time, according as the Earth advances in its Orbit. For after the *Pleiades*, you will behold the glorious Conſtellation *Orion* here, and the *Canicula*, or *Procyon*, begin to ſhew themſelves towards the South and Eaſt; and upon the North the *Twins* here, *Caſtor* and *Pollux*. As the Year advances, the Conſtellations of *Leo* and *Hydra* begin to appear. And from the South, *Sirius*, the brighteſt of all the Stars, ſhews himſelf, blazing fiercely below the Equator; and far behind him to the Eaſt here, the *Celeſtial Virgin* with her *Spica*. Towards the End of Winter, *Arcturus* comes in view, while *Bootes* drives about his *Wain* from the North: At which time you may perceive almoſt all the Stars of the greateſt ſplendor at one view. For *Lyra* and the *Swan* here, as alſo *Capella*, *Perſeus*, with the *Gorgon's* head, and all that *beautiful Region*, either keep near the Vertex of the Sky, or dip but little under the Horizon.

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Theſe things will make your walks in the Winter evenings agreeable; nor can you procure to yourſelves a more refin'd and innocent pleaſure: Not to mention how ſtupid it is, to neglect ſuch wonders in the evenings, as if we were bow'd down like the groveling Brutes. As the Winter-time, and the long clear nights, are fitteſt for this purpoſe, that ſeaſon will return with pleaſure: Every thing will renew your acquaintance; you will, when you are acquainted with this pleaſant amuſement, have a chearful temper, and find rational entertainment.

The Antients in general allude ſo often, and ſo particularly, in their poems to the Conſtellations, that there is no underſtanding the latter, without underſtanding the former: And this may be another good reaſon, why you ſhould be very attentive to *theſe* other Conſtellations. The Antients were of opinion, that their moſt conſiderable Men, after their deceaſe, were tranſported into ſome *Star* or *Conſtellation*: As we ſay of the Departed, *He was a good Man, and is gone to Heaven*, they us'd to ſay, *He was a great Man, and is made a Star of*. They had ſome notion of theſe Stars being very large; a ſort of Worlds ſpread about the great Expanſe. *Arcturus* with them was the *Intelligence* of one of theſe *Worlds*; as *Perſeus* was ſuppos'd to preſide over ſeveral of them: Each of the other Conſtellations, according to them, had its preſiding *God*. *Plautus* has a fancy about the Stars, which however odd, may at leaſt ſerve to ſhew the opinion that had obtain'd. He introduces *Arcturus* to ſpeak the Prologue of one of his beſt Comedies, the *Rudens*—*Arcturus* ſays in it, " That he is one

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Since the Sun appears always to move the contrary way to the Earth; ſince he darkens, by his ſplendour, that part of the Heavens in which he is ſeen; and ſince the point of the Heavens oppoſite to the Sun is that which is on our Meridian at mid-night, as he is at mid-day, we may know from looking at the Heavens themſelves at that hour, mid-night, both the point of the Heavens in which our Earth is, as being then on our Meridian, and the point in which the Sun then ſeems to be, as being directly oppoſite to the other. For if the firſt degree of *Libra* be on our Meridian at mid-night, the Earth, to an Eye placed at the Sun, would appear to be in that point: Whence we know that the Sun is in the oppoſite point, or in the firſt degree of *Aries*, which happens about the 10th of *March*: And thus they proceed, occupying ſtill oppoſite points, through all the following Signs of the *Zodiac*.

And now to give you a method of finding out, in the Heavens themſelves, the Signs of the *Zodiac*, as this ſpace here is called, where certainly there are no effigies of the Creatures, whoſe names the Signs bear, as on this Celeſtial Globe before us. ——The Degrees are reckoned from the firſt of *Aries* eaſtward, or through the *following Signs* this way, in every Sign thirty degrees. Hence the Signs themſelves are known and limited; ſince each of them takes up the twelfth part of the Ecliptic. And thus it is known what Stars are contain'd in ſuch a ſpace, ſo that they can be reduc'd to their proper Sign and the degrees of that Sign: And when once a few are known, we come to the knowledge of the reſt without difficulty. As for example; the *Pleiades* are in the 26th degree of *Aries*, and 4 Degrees diſtant from the Ecliptic, eaſtward. From theſe you will eaſily diſcover both the names and places of the neareſt Stars, and from theſe again others; remembring always to make yourſelves acquainted with the greateſt Magnitude firſt, for theſe will direct you beſt. And thus you may make a Map as it were of this part of the Heavens: and to that purpoſe this artificial Globe will be of uſe, as you have on it the names and places of the Stars marked, and as you may conſult the Heavens and Globe by turns; eſpecially when you know how to ſet, or rectify the poſition of the Globe, that it may repreſent the face of the Heavens at any particular time. You will alſo eaſily perceive that the Winter time, and the long and clear nights are fitteſt for this purpoſe.

Let us now imagine ourſelves, in good earneſt, to be carried round the Sun with the Earth; and let us begin from the firſt degree of *Libra*.——The Earth being there, the Sun muſt be in the firſt degree of *Aries*; and you may fancy, that this is about the 10th of *March*, or *Vernal Equinox*. Call to mind likewiſe that the *Axis* of the Earth points conſtantly to the *Pole* of the Heavens; that point namely which ſeems immovable in the Earth's diurnal revolution: For by this means, becauſe of the immenſe diſtance of the Heavens, the *Axis* keeps ſtill parallel to itſelf. In order to underſtand this, you muſt imagine a Diameter drawn through the Earth's Orbit from North to South, or from the firſt degree of *Cancer* to the firſt of *Capricorn*: And if the Earth's Axis be produced, when it is in the

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For all our meaſures, and ſenſible images, are ſwallow'd up here, without being known; and the only ſenſible repreſentation of this diſtance is this: You muſt know that the Diameter of the *Magnus Orbis* is upwards of forty thouſand times the Semi-diameter of the Earth itſelf, according to the common computation of the Sun's diſtance; that is, upwards of a hundred and ſixty millions of miles. Now when the Earth is in the oppoſite parts of its annual courſe, repreſented in this ſcheme before us, or hath really advanced a hundred and ſixty millions of miles near ſome of the *Fix'd Stars*, and hath left others of them ſo much behind, it ſeems not to have chang'd its place with reſpect to them, nor they to have alter'd their Situation with reſpect to each other in the leaſt: Which could not be if this Diameter of the *Magnus Orbis* bore any aſſignable proportion to its diſtance from the Fix'd Stars. Conſider this a little.—Juſt as if you ſhould travel a hundred and ſixty thouſand miles ſtrait forward every year, for a thouſand years together, and yet never perceive yourſelves draw nearer certain immovable bodies, that were before your faces, nor farther from others, that you ſee left behind your backs; and if one particular body, in all that long journey, ſhould ſtill appear with the ſame degree of elevation above your heads;—you plainly ſee the conſequence?—Thoſe bodies muſt, indeed, be at an inconceivable diſtance from

you;

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you; and the ſpace you travel over muſt bear no proportion to their diſtances; otherwiſe they would ſeem to have chang'd their ſituations among themſelves; as the objects in a large plain are thrown into a different order, while you travel through it. You are really carried thus far, not indeed once in a thouſand years, but twice in one year. For, in effect, you are, about the 10th of *June*, a thouſand times a hundred and ſixty thouſand miles further from the northern parts of the Heavens than you were the *December* before: And yet you perceive your ſituation, with reſpect to them, no ways changed.——This then helps you to underſtand that *immenſe Triangle*, we ſuppos'd drawn, of which this Diameter of the *Magnus Orbis* was the Baſe; and that the two ſides meeting in the Pole of the Heavens, were yet, with reſpect to our perception, parallel. Whence we inferred that the Baſe was but as a point in compariſon of the ſides: And from thence, you perceive, we rightly inferred the Parallelliſm of the Axis of the Earth to itſelf, in all its annual Courſe; to which chiefly we owe our diverſity of ſeaſons. Since in the immenſity of ſpace, the greateſt luminous bodies muſt diſappear, were they remov'd to a due diſtance, their different apparent Magnitudes may be owing to their different diſtances; allowing they were all equal among themſelves. This Boundleſſneſs of the material Univerſe diſtreſſes the imagination, and is literally inconceivable! The mind of Man only reſts ſatisfied with thoſe effects of Almighty Power, the greatneſs of which it can neither conceive nor ſearch out; and this whether we conſider the grandeur, the number, or the ſubtilty of his works: In this ſingular view, the Power of the Deity offers itſelf to be revered and adored by us!

This ſcheme before us will help your imagination; for there you perceive *Aries* on your right hand, and *Libra*, whence you are to ſet out, on your left. Remember that the Earth rolls on its Axis, or performs the diurnal Revolution all the time it is carried round the Sun. For if that larger Globe repreſent the Sun, and this *ſmall one* the Earth, the Equator of the Earth, in this poſition, is now exactly oppos'd to the Sun, and he always enlightens a *Hemiſphere*, or half of its ſurface, his rays reaching to both Poles. Whence from the diurnal Revolution of the Earth, the days and nights are equal all over the Globe; for we are in the rays of the Sun for one half the diurnal Revolution, and in the ſhadow, or dark, for the other half.

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As we proceed daily with the Earth towards the South, thro' *Libra*, *Scorpio*, and *Sagittarius*, to the beginning of *Capricorn*, the Sun ſeems to riſe above the Equator, and move to the North, thro' the oppoſite Signs *Aries*, *Taurus*, and *Gemini*, to the beginning of *Cancer:* The Axis always reſpecting the *North-Pole* of the Heavens, is now more turn'd to him; therefore he muſt be on the North of the Equator.

And this is the reaſon why he ſeems to riſe higher to us: For ſince over our heads is always *upwards* to us, as the Axis, keeping parallel to itſelf, turns us more to him, he appears to riſe higher to us. And for the ſame reaſon, the *South-Pole* turning from him he ſeems to fall lower to them. The Earth being arriv'd at *Capricorn*, in this poſition of the Earth, the Sun's rays fall ſhort of the *South-Pole*, and reach beyond our *North-Pole*, even to the fartheſt ſide of the *Arctic Circle* here; and on the oppoſite part they reach only to the nearer ſide of the *Antarctic Circle:* Whence the firſt is all in Light, and the laſt all in the Earth's ſhadow, for he muſt ſhine as far beyond the one Pole, as he has advanc'd nearer it, and as far ſhort of the other, as he has receded from it. Being now at the 10th of *June*, and having travelled with the Earth through the firſt Quadrant of the Ecliptic; we are moving ſtill fowards caſtward, through *Aquarius* and *Piſces*, to the firſt of *Aries;* and the Sun the contrary way, from the Tropic of *Cancer* through *Leo* and *Virgo*, to the firſt of *Libra*; And the motion through this Quadrant is only the converſe of its motion in the laſt; as the Sun muſt loſe of his altitude, or ſeem to deſcend to the Equator again: And the days muſt be ſhortened from the Solſtice to the autumnal Equinox, in the ſame manner as they were lengthened from the vernal Equinox to the Solſtice.

The Earth moving North from the Sun, when it leaves the firſt of *Aries* about the 11th of *September*;

the North-Pole is turn'd gradually away from him, and the South-Pole is turn'd more to him. Whence he ſeems to fall down below the Equator to us, and ſo riſe higher to thoſe on the other ſide of it; for over their heads is *upwards* to them likewiſe. Being now arriv'd at the beginning of *Cancer*, the Sun appearing in *Capricorn*, our night is become as long as our day was in the oppoſite Solſtice, and the day as ſhort as the night was then. This is a beautiful Regularity! By this motion you may perceive that the bounty of Heaven reaches all the inhabitants of the Earth? If we take the altitude of the Pole at the extreme parts, the North and South, of the Earth's Orbit, we ſhall not find it rais'd any higher in one part than the other, though we have been carried towards it by a whole length of a Diameter of the *Magnus Orbis*: Whence you may conceive it but as a point compar'd with the diſtance of the Fix'd Stars. But the better to help your conception of the matter, let S, in this ſcheme on the floor, be the Polar Star, ODRI the *Magnus Orbis*; SE be perpendicular to the Plane of the Orbit produc'd; D the place of the Ecliptic, where the Earth is, in the Winter Solſtice; and I the place in the Summer Solſtice. Alſo let the Lines SI, and SD reach from the Star S to the center of the Earth, placed in the points D and I, at the reſpective Solſtices, and let the eye of the ſpectator be in thoſe points. AQ, in both Solſtices, is the Earth's Equator; and PX its Axis, always parallel to itſelf; and the poſition of the ſpectator's eye, viewing the Polar Star, in both Solſtices, is repreſented by the points D and I.

Now, if there be no alteration of the Angle SIE, when the Earth comes into the poſition SDE, the Star S, at the points D and I, will be equally diſtant from thoſe points; and the Star S will be reckon'd, as it were, at an infinite diſtance, as the whole Diameter of the Earth's Orbit will then be taken only as a point, or the Angle DSI, which the Diameter DI ſubtends, will vaniſh away; being, as it were, infinitely ſmall. On the contrary, if the Angle SDP be leſs than the Angle SIP, the Angle DSI, which is equal to the difference of the Angles SDP and SIP, will be ſenſible, and will be the annual Parallax, as it is called, or the Angle ſubtended by the Diameter of the Earth's Orbit:

And

Aſtronomy. And the latitude of the Polar Star, S, at the Winter Solſtice, that is, the Angle SDE, will be greater than the latitude of the ſame Star, at the Summer Solſtice, that is, the Angle SIE.

Now, by the Obſervations of ſome eminent Aſtronomers, it appears, that the Earth is ſenſibly nearer the Polar Star at the Winter Solſtice, than it is in the oppoſite part of its Orbit; that is, the Angle SDE is greater than SIE; *if ſo*, then conſequently there is really an *annual Parallax*. And by that means we may, by being duely prepar'd with our Meaſure, make our approaches to the wide Expanſe to make our general Eſtimate. For as the Diameter of the *Magnus Orbis* is ſaid to bear a certain proportion to the diſtance of the Polar Star; then, by Trigonometrical Calculation, the diſtance of the Polar Star will be about nine thouſand Semi-diameters of the *Magnus Orbis*.

But by reaſon of this prodigious diſtance of the Fix'd Stars, the *annual Parallax* is ſo exceeding ſmall, that it is *extremely* difficult to take it, with any tolerable accuracy, even with the beſt inſtruments that ever were invented. For notwithſtanding the above Calculation, other famous Aſtronomers ſay, the *annual Parallax* is much ſmaller, than has been hitherto given in; even not to amount to the 40th part of it: And this, inſtead of making the Polar Star 9000 Semi-diameters of the Earth's Orbit, increaſes it to above 400,000 times the diſtance of the Sun from the Earth! This is prodigious!

From this chill Solſtice, we move South, and the Sun ſeems to return Northward; till the Earth coming again to the firſt of *Libra*, finiſhes its *annual Courſe*, having in the mean time performed 365 *Revolutions* on its Axis, and thereby divided the year into as many days.

And now, from what has been ſaid, you may eaſily conceive, what would be the face of things, if the Equator and Ecliptic co-incided into one. For then the Sun would be conſtantly vertical to the Equator; and by that means there would be a conſtant Equinox, or

equa-

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equality of day and night, all the Earth over; in the ſame place there would be no diverſity of ſeaſons. And, indeed, in this ſituation, the annual motion of the Earth, round the Sun, would, perhaps, be needleſs for this Purpoſe, only; ſince we ſhould have the ſame degree of Heat and Light from him, if the Earth ſtood ſtill in the ſame part, and revolv'd on its Axis, as at preſent: Only by this one motion, indeed, we could have but one face of the Heavens, the ſame Stars being conſtantly expos'd to our View, in the night-time, which would deprive us of a moſt pleaſing variety. In theſe parts, where we live, it is very much to be doubted, if we could have any harveſt, or ripeneſs of vegetables, as we ſhould not then have much more Heat than now, about the middle of *March*: In other places, an eternal Winter, without the hopes of a returning Spring, would baniſh Mankind from a great part of the now habitable Globe.

Certainly it is wonderful, that from ſuch a ſmall Inclination of the Earth's Axis, to the Plane of the Ecliptic, and the paralleliſm of its Axis, ſo many agreeable viciſſitudes, and ſuch advantages to Mankind, ſhould ariſe!

And now, What may your thoughts be of the various appearances of the Moon?——You know as ſhe is an opaque body, and therefore neceſſarily reflecting the Sun's rays, ſhe muſt appear of different forms to us, as the Hemiſphere, enlighten'd by the Sun, is more or leſs turn'd to us. Therefore in the *Conjunction*, here in this ſcheme before us, ſhe is quite inconſpicuous; except, perhaps, by appearing on the face of the Sun in an Eclipſe, as a dark circle. In the *Oppoſition* here, ſhe muſt appear *full*; for her ſide, to which it is then day, is expos'd to us; and between *theſe two* ſhe muſt put on all the *intermediate Appearances*. You may eaſily conceive from this, why before and after the *Change*, her Horns are turn'd contrary ways, ſtill from the Sun; and her luminous Edge towards him; for her enlighten'd Half is then going out of, or coming into our view.

The Earth puts on all the ſame variety of appearances to the Moon, as ſhe does to us, but in a contrary

Aſtronomy. trary order. When we have the *new Moon*, the Earth muſt appear at the *full* to her; for her dark ſide being then towards us, it is night there. As her Light increaſes to us, ours muſt decreaſe to her, by being carried more towards the dark ſide of the Earth, and ſo turning her own illuminated Half to us; till ſhe comes to the oppoſition, and ſhines full on us, when the Earth muſt be quite darken'd to her, unleſs at ſome particular times in *this Conjunction*, it comes over the Sun, and wholly covers him from the Moon. For the Earth muſt appear a much larger body at the Moon, than the Sun himſelf, when the Earth not only covers the Sun wholly, but hides a great ſpace of the Heavens round about him from a Spectator in the Moon. You may, by this ſcheme before us, ſee plainly that the Moon takes a long time to wade through the ſhadow of the Earth, which is, even there, near four times broader than herſelf. Now if the Plane of the Moon's Orbit coincided with the Plane of the Ecliptic, there would be a total Eclipſe of the Moon every *Oppoſition*, or when the *Earth* is in *Conjunction*; and a central Eclipſe of the Sun every *new Moon*, according to the diſpoſition of this Apparatus before us. But as the path of the Moon is oblique to the path of the Earth round the Sun, ſo there are but two points in the Moon's whole Courſe, where ſhe comes exactly into the Plane of the Ecliptic; being every where elſe either above or below the ſaid Plane, which is the reaſon that Eclipſes happen ſo rarely. For except the Moon, at the *Full* or *Change*, is in or near one of the *Nodes*, the two points mention'd before, and repreſented here in this Machine, there will be no Eclipſe; becauſe when her *Latitude* or Diſtance from the Ecliptic, exceeds the ſum of the apparent Semi-diameters of the Moon and Earth's ſhadow, and ſhe comes at that time to the full, then, as the Axis of the Earth's ſhadow always lies in the Plane of the Ecliptic, the Moon will be too far on one ſide or other of it to ſuffer any Eclipſe. If the New Moon happens when her Latitude exceeds the ſum of the apparent Semi-diameters of the Sun and Moon, the Moon's ſhadow will fall on one ſide or other of the Earth, ſo as not to touch it, and there will be no Eclipſe of the

Sun.

If, as in this Machine before us, the Moon's path had lain in a Plane, croſſing the Plane of the Earth's Orbit, at right Angles; and the common Section of the two Planes always paſſed through the center of the Sun, the Moon would, then indeed, in every revolution, have been in conjunction with, and oppoſition to, the Sun as now: As alſo this Plane, lying through the Sun and Earth, ſhe never would have been behind, or before the Earth, in its annual courſe; but ſtill equally advanced with it. For this Plane ſtanding erect above the other, muſt have moved round as the Earth moved; ſo as to paſs always through the Centers of the Sun and Earth; but ſtill we ſhould have had our full and new Moon regularly as at preſent; and then the Moon muſt have come over our heads from North to South, or from South to North at leaſt, through the Poles of the Ecliptic, and conſequently through or near the Poles of the World. If you conſider this circumſtance, you will ſee, that the Plane of her Orbit muſt always have paſſed through the Poles of the Ecliptic. And ſince our elevated Pole always points to the North, her Plane muſt have paſſed thro' the Poles of the Equator too, when the Earth was in the Solſtices; for paſſing ſtill through the centre of the Sun, it muſt have then lain directly South and North; as appears in the ſituation of the rings of this Machine. And at all other times it muſt have paſſed a little beſide the Poles of the World. Aſtronomy.

Then the diurnal revolution of the Earth could not have caus'd the Moon to riſe and ſet to us every day, as ſhe does now; for when ſhe was about the South-Pole, we could not have ſeen her for many days, more than now we ſee the ſouthern Conſtellations, which never appear above our Horizon. All the time likewiſe ſhe ſhould be about the northern parts of the Globe, ſhe muſt be hid to thoſe lying on the other ſide of the Equator. And ſince ſhe muſt always have moved upon, or near a vertical Circle, paſſing through the center of the Sun, ſhe muſt for half of her Menſtrual courſe have come to our Meridian almoſt at the ſame time with the Sun, or about twelve o'Clock of the day. That is, our Moon-light muſt have happen'd for the half of her revolution, by day, when it

Aſtronomy. could not have been perceiv'd, or done us any ſervice. Things would have been different from what they are now in moſt other reſpects: Our periodical and ſynodical months would have been the ſame; and the Tides muſt have ſwelled for ſome days together about either Pole, once a month, without a Tide on the oppoſite part of the Globe, as now; and there muſt have been an *Eclipſe* of the Sun every *Conjunction*, and of the Moon every Oppoſition: Becauſe the Plane of the Moon's Orbit paſs'd through the Centers of the Sun and Earth. And thus we may go on to conſider the conſequences of any other ſituation of the Moon's Orbit. And theſe ſeveral circumſtances may, I think, ſuggeſt to us the inconveniencies we ſhould have ſuffer'd, if the Earth itſelf had thus moved from North to South, inſtead of moving from Weſt to Eaſt.

We plainly ſee great inconveniencies from ſome diſpoſitions, differing from the preſent, that were equally poſſible. This ſhews us the kindneſs of the Creator, in the preſent order and motions of the Heavenly Bodies. But ſuppoſing other diſpoſitions might, in ſome reſpects, have been equally advantageous; we have even then nothing to complain of, becauſe God hath choſen one of two ways which were equally proper.

The ſame reaſoning ſeems to be applicable to other Planets, and the Moon's revolving about ſome of them, as thoſe Planets in particular muſt have been leſs carefully provided for, had the Planes of their Satellites lain acroſs the common Plane.—The greateſt Philoſophers loſe the beſt part of their pleaſure ariſing from the ſtudy of Nature, for want of ſuch obſervations. You may now underſtand, in general, the beauty and uſefulneſs of the preſent diſpoſition, and even ſhew to another the inconveniency and loſs we ſhould have ſuſtain'd if things had been in ſome circumſtances otherwiſe. But it is enough that we ſee the preſent diſpoſition wiſe and regular; nor are we to imagine that we can come at the knowledge of, or diſcover *all the Reaſons*, why things are order'd ſo.—It is ſufficient for us to know what relation the Heavens bear to our Wants, and to adore a Wiſdom ſo infinitely ſuperior to our own.

CHAP. III.

The Uſe of the ORRERY, *in explaining the Motions of the* Solar Syſtem.

IT was of importance to you, to take a view of the immenſe regions of ſpace, unaſſiſted by Machines and Schemes, where it could be done, ſo as to give you a tolerable idea of what was deliver'd. The beſt mechanical devices are apt to give you a narrowneſs of conception, which diſtreſſes your imagination: On the contrary, by making the wide Expanſe your Diagram, this gives you becoming ſentiments, warms and elevates your ſouls, and enlarges your views of Nature, by the grandeur of its ſpeculations. However, to make a deeper impreſſion upon your minds, and to explain ſome things in Aſtronomy, deſignedly omitted, and to give *you*, who have not well digeſted what has been ſaid, a better idea of the ſubject, I ſhall proceed to ſhew you *all*, how well adapted this large and beautiful Machine, before us, is to the purpoſes of Aſtronomy. Aſtronomy.

To fix in your minds a juſt idea of the Proportional Magnitudes of the Solar Syſtem, I ſhall make uſe of this ſet of Orbs, whoſe ſizes are proportion'd to one another, as the *Magnitudes* of the *Planets* are, according to the diſcoveries of the beſt Aſtronomers. In this illuſtration a proportional Sun cannot be made uſe of; but this defect is ſupply'd by imagining a Globe, that would fill the ſpace contain'd within *this* Circle, which is call'd the Orbit of *Jupiter*.

This Ball repreſents the *Earth*, and this the *Moon*; and next to the Earth, and nearer the Sun is *Venus* here; and neareſt to the Sun is the Repreſentative of the Planet *Mercury*: More diſtant from the Sun, and next to the Earth is *Mars*; further ſtill from the center of the ſyſtem is *Jupiter*, which is repreſented by this large gilt Globe: And laſtly, the moſt diſtant from the Sun, Aſtronomy. Sun, of all the primary Planets is *Saturn* here, with its marvellous Ring or Arch.

The Proportions of the diſtances of theſe heavenly Bodies, from the Sun, are nearly as follow: Suppoſing the diſtance of the *Earth* from the *Sun* to be divided into ten equal parts, of theſe the diſtance of *Mercury* will be four, of *Venus* ſeven, of *Mars* fifteen, of *Jupiter* fifty-two, and that of *Saturn* ninety-five.

And now to give you a general idea of the Planetary Syſtem, I apprehend the eaſieſt method will be to advance to it by an induction of particulars; and therefore by removing all the Planets out of the Orrery, this gilt Ball, which I am now fixing, is the Repreſentative of the Sun, that immenſe ocean of Heat and Light! In the whole immenſity of the Heavens, this glorious body alone, when he appears in the Heavens to us, overſpreads nature with ſplendor and glory; and diffuſes its ſelf through the whole ſyſtem of wandering Globes, that ſtand in conſtant need of his enlivening rays and aſſiſtance.——By turning about this winch or handle, you do not find that the Sun is remov'd out of his place; but you obſerve that his Orb turns upon its Axis, which is made apparent by the ſeveral ſpots on his ſurface.

This Ball is the *Repreſentative* of the *Earth* we live upon.——Now by turning the handle, we obſerve the Terreſtrial Globe rolls upon its Axis with greater ſpeed than the Sun: And to find how much ſwifter the motion is, we are to look upon *this Dial*, and we ſhall ſee, that one turn of the winch carries this Hour-Hand or Index once round through all the 24 Hours, which makes our natural Day: And at the ſame time the Earth alſo compleats an entire revolution upon its Axis. But the Sun, at the end of this term, has but advanc'd a ſmall part of his Revolution; one turn of the handle more makes the Earth perform another diurnal period, and the Sun has advanc'd as much as he did at the firſt. And thus repeating of the turns of the handle, we ſhall find at laſt, that when the Sun's Orb has finiſh'd his period, or has turn'd quite round, the Earth will have made 25 turns and about a quarter.——For we will begin this experiment again, and ſet this Hour-Index to twelve, and the other hand to the beginning of the 60 diurnal diviſions, and we ſhall ſee, at the end of one period of the Sun, that the Diurnal Index ſtands at 25 days, and the Hour-Index at ſix hours. This may clearly illuſtrate ſo much of the ſyſtem, that the Earth turns round its Axis in 24 Hours, and the Sun in 25 days and ſix hours.

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This Terreſtrial Ball before you, has the ſeveral Meridians, the Equator, Ecliptic, Tropics, and Polar Circles drawn upon it; as alſo a ſketch of the Countries and Oceans, in the ſame manner as they are deſcrib'd upon common Globes; and you may obſerve its Axis is inclin'd to the Plane of this Ecliptic on the Orrery, in an Angle of 66½ Degrees as it is in Nature. And this *Wire-Index*, ſupported upon theſe two props, in this part of the Earth's Orbit, which is exactly oppoſite to the Earth, points from the Center of the Sun to this large *Braſs Ecliptic*; and thereby ſhews the Sun's place at all times, or againſt what Fix'd Stars in the Heavens he appears, as beheld from the Earth, and alſo the correſpondent month and day of the month.

Before I explain the Appearances which particularly belong to the Earth, and which entirely depend upon its Poſition and Motion, I ſhall prevent its Diurnal Revolution, in order to make the effects of its periodical journey round the Sun more intelligible to you.

You ſee I bring about the Earth's plate till we ſee the Sun's place, by this *Wire-Index*, to be in the beginning of *Cancer* on the 10th day of *June*. And by fixing this other *Wire*, which I ſhall call a *Solar Ray*, you ſee it points to the Tropic of *Cancer*, drawn upon the Earth, and the North-Pole ſtanding towards the Sun. Now turning about the handle, you perceive the Earth begins to move in its Orbit; and the Sun appears to proceed thro' *Cancer* towards *Leo*: At the ſame time the *Solar Ray* deſcribes the Ecliptic upon the Earth, receding from the North towards the South: So that when the Earth has gone over a Quarter of its Orbit, and the Sun appears entering into *Libra* on the 11th of *September*, the Solar Ray points exactly at the Equator.

And

Aſtronomy. And turning the handle ſtill about the Ray purſues the Courſe of the Ecliptic, as drawn on the Earth, toward the South, till the South-Pole is turn'd towards the Sun, and the Index which ſhews the Sun's place, comes to the 10th of *December*, when the Earth has performed one half of the Revolution, and then the Solar Ray has gain'd the Tropic of *Capricorn*, which is the Sun's limit towards the South. From thence the Solar Ray reverts along the Ecliptic towards the North, and comes to the 10th of *March*, when the Sun enters into *Aries*, to point again at the Equator, the Earth having performed three fourths of its Revolution: The winch being ſtill in Motion, the Solar Ray ſtill approaches the North; and at the end of 365 days and 6 hours, the Earth having compleated its period, the Sun again ſtands at the beginning of *Cancer*, and the Solar Ray points at the Tropic, which is the limit of the Sun's acceſs to the North. Thus you plainly ſee the apparent Courſe of the Sun thro' the Ecliptic, and its various poſitions, at different ſeaſons, in the northern and ſouthern parts of the World.

This ſmall braſs Arch, in the form of a Creſcent, wanting about 47 degrees of an entire Circle, is ſupported upon theſe two props, at the end of this wire, which ſupports it vertically, and hangs over, as you obſerve, and encompaſſes the upper part of the Earth perpendicularly, or at right Angles to the Solar Ray. This Arch therefore divides the Globe of the Earth into two equal Parts or Hemiſpheres; thereby defining and marking out that Hemiſphere, which at any time is turn'd towards the Sun, and ſeperating it from the other, which is turn'd or hid from the Sun. As this Arch thus divides the enlighten'd from the dark part of the Earth, it has Day engrav'd upon that ſide which faces the Sun, and Night upon the other.

The *Earth*, with the Arch, which we ſhall call the *Solar Horizon*, ſtanding at the firſt degree of *Cancer*, as before, I ſhall now diſcharge the annual Motion of the Earth, and reſtore its diurnal Revolution. You obſerve, in this *Poſition* of the *Earth*, that the *North-Pole* is turn'd towards the *Sun*, and all that part of the Globe, within the *Artic Circle*, lies in the enlighten'd

Hemiſ-

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Hemiſphere, or Day; the *South-Pole* and *Antarctic Circle* being totally turn'd from the Sun into the darken'd Hemiſphere or Night, and all the reſt of the Earth is divided into two equal ſhares of Day and Night, by the *Solar Horizon*. Now by turning the handle, you may obſerve, that all places, which lie between one Polar Circle and the other, are carried from Weſt to Eaſt, as the Arch ſhews by the points mark'd W and E, and appear and diſappear alternately, upon the light and dark ſides; that is, every particular ſpot, within either of the Temperate or Torrid Zones, by one turn of the handle, will be made firſt to appear to the Sun, under the Weſtern edge of the Solar Horizon, the Sun at the ſame time riſing or appearing to be in the Eaſt: From thence paſſing forwards through the enlighten'd Hemiſphere, it will diſappear under the Eaſtern edge of the Solar Horizon, the Sun then ſetting in the Weſt: Thence, by continuing the motion of the handle, it will paſs through the darken'd Hemiſphere or Night, and appear again in the Weſt as before. But this rotation does not occaſion any place in the Northern Frigid Zone to diſappear, becauſe the whole Arctic Circle lies in the enlighten'd Hemiſphere, or on that ſide of the Solar Horizon next the Sun: Neither does any place in the Southern Frigid Zone appear in the day, the whole Antarctic Circle being turn'd from the Sun, beyond the Solar Horizon. By going on the ſame Experiment again, you may obſerve, that all places on the Equator here continue in the day and night, equal times; but thoſe to the North of the Equator, have longer days than nights; and the more ſo the further North they are ſituated, till approaching to the Arctic Circle, it becomes all day and no night. On the contrary, thoſe places to the South of the Equator, have ſhorter days than nights; which inequality ſtill increaſes to the South, till we gain the Antarctic Circle, and, from thence to the Pole, all is night and no day.

You may accurately obſerve the lengths of day and night in any place, by bringing the place under the Weſtern edge of the Solar Horizon, and putting this Hour-Index to XII. and by my turning the handle till the ſaid places come under the Eaſtern edge of the

Aſtronomy. Solar Horizon; there ſtopping, we ſhall ſee how many hours the Index has paſſed over, which is the true length of the day in that place. Then putting the Index again to XII. and turning the handle, till the place having paſſed through the darken'd Hemiſphere returns under the Weſtern edge of the Solar Horizon, the hours paſs'd over will ſhew the length of the night. Thus, by having any City or Town given, you may know how many hours there are between the Sun riſing and ſetting, and between the Sun ſetting and riſing.

If I turn the Earth's plate about, till the Earth comes to the beginning of *Aries*, and the Sun to the firſt degree of *Libra*, on the 11th of *September*; you may obſerve the two Poles to come under the Solar Horizon, and one half of each Polar Circle in the day, and the other in the night: As alſo the Tropics, and all the Parallels of Latitude, equally divided by the Solar Horizon; ſo that by turning the handle about, all places upon the Globe will be ſhewn to enjoy equal portions of day and night, except the Poles, which remaining unmov'd on the limits between Light and Darkneſs, cannot properly be ſaid to have or to want either day or night.

By my bringing the Earth's plate about till the Sun comes to the beginning of *Capricorn*, and the Earth to *Cancer* on the 10th of *December*, the North Pole and the Arctic Circle will be turn'd, as you ſee, into the night, and the Antarctic Pole and Circle, into the day. So that every thing will happen exactly the contrary of what was obſerv'd before; the days now being longeſt, and the nights ſhorteſt, to the ſouthern parts of the World; and the nights longeſt and days ſhorteſt to the inhabitants of the North.

The Earth being remov'd to the beginning of *Libra*, and the Sun to *Aries*, on the 10th of *March*, day and night will again be ſhewn equal all the World over.

Thus you have had all the four Cardinal Points of the year fully explain'd; that is the two Solſtices and two Equinoxes, which define the beginning of the Spring, Summer, Autumn, and the Winter quarters.

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Now by puſhing in this ſtop, the Earth will perform both its Rotation upon its Axis, and alſo its annual Revolution, by which the Sun will relatively be carried thro' the Ecliptic, according to the order of the Signs, and in the compaſs of 365 days and 6 hours by the Dial; the whole uninterrupted progreſs of the year through the four ſeaſons, and the Sun's courſe through the Zodiac, will be compleated, and illuſtrated by the Solar Ray and Horizon, after the ſame manner as the four Cardinal Points were before.

To explain other particular Phænomena, depending upon the poſition and motion of the Earth, and to make the various appearances of the Sun in the courſe of the year, ſtill more delightful to you, I ſhall put in this Ball, which alſo repreſents the Earth, whoſe Diameter is three inches. It has, as you may obſerve, a Map of all the known Terraqueous Globe, neatly delineated, and colour'd upon its ſurface. To this Globe you may ſee is fitted this ſilver'd Horizon, mark'd with Circles and Diviſions, like that belonging to a common Globe: To which is fix'd, you ſee, a graduated Meridian, with this pin at 90 Degrees diſtance from the Horizon. And as the Meridian and Horizon are eaſily moveable, this pin being brought to any place, and the Meridian being brought to its due North and South poſition, the Horizon will be truly adjuſted to that place.

The pin being brought to the North-Pole, the Horizon will exactly coincide with the Equator; which condition of the Globe is call'd a *Parallel Sphere*, all the Parallels of Latitude being parallel to the Horizon. Now, if I put the Globe thus order'd into the Orrery, and ſet it in due poſition at the firſt degree of *Libra*, then will the Solar Ray point directly to the edge of the ſilver'd Horizon; and the handle being gently turn'd round, the Earth will roll upon its Axis, the Solar Ray tracing along the Horizon, without deviating in the leaſt to the North or to the South: Which ſhews that, on the 10th of *March*, the Sun does not appear to the Terreſtrial Poles, either to riſe or to ſet, but paſſes through all the points of the Compaſs, the Plane of the Horizon ſtill beſecting the Sun's Diſk. But, giving the Earth its annual motion, and continuing to turn the handle, the Solar Ray, and conſequently the appearance of the Sun, will, in a few days, be obſerv'd to have left the Horizon, and to come into the Northern Hemiſphere, ſtill approaching nearer and nearer to the North Pole, for three months together; that is, from the 10th of *March* to the 10th of *June*: In which time the Sun, in his apparent diurnal motions, has deſcrib'd a Spiral, or rather Helix, whoſe Baſe is the Equator, and Vertex the Tropic of *Cancer*; at which point, being the Summer Solſtice, the Sun will appear to the North Pole, for the ſpace of many days together, not to be ſenſibly leſs than 23½ Degrees high. From thence the Solar appearance, explain'd by the Solar Ray, gradually winds its Helix back again, and arrives at the Horizon and Autumnal Equinox, on the 11th of *September*, the Earth then entering into *Aries*, and the Sun into *Libra*; the North Pole having had continual day, and the South Pole having been hid in the night for half a year. But now the operation being carried on, the Solar Ray gains the Southern Hemiſphere, making ſix months day to the South Pole, and night as long to the North, after the ſame manner as before explain'd, arriving on the 10th of *December* at the Winter Solſtice, and thence returning to the Vernal Equinox on the 10th of *March*, which in this caſe coincides with the Horizon as before.

The pin being remov'd from the North Pole, and placed any where in the Equator, the ſilver'd Horizon will encompaſs the Earth, ſo as to paſs through both Poles. The Globe in this Poſition is call'd a Right Sphere; the Equinoctial, and all the Parallels of Latitude, ſtanding at Right Angles, or perpendicular to the Horizon. Then, turning the handle till the Earth compleats a year, or one Revolution about the Sun, you will obſerve all the Solar appearances as they happen to the inhabitants of the Equator, to be clearly illuſtrated; that is, that 1. the Sun riſes at ſix, and ſets at ſix o'clock all the year long; and conſequently, that the days and nights are perpetually equal. 2. That about

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about the 10th of *March* and 11th of *September*, the Sun at Noon is in the Zenith, that is, vertical to, or exactly over, the heads of the inhabitants. 3. That one half of the year, between *March* and *September*, the Sun is every day at noon full North, and the other half, between *September* and *March*, it bears full South; the Meridian Altitude being never leſs than 66½ Degrees, which occaſions the exceſſive Heat and Intemperance of the Torrid Zone.

The pin being remov'd out of the Equator, and ſet upon any place between the Equator and the Poles, the Horizon will not then paſs through either of the Poles, nor coincide with the Equator, but cut it obliquely; one half of the Equator ſtanding in a ſloping poſition above, and the other below the Horizon. The Globe thus order'd, is call'd an Oblique Sphere; of which there are as many varieties as places between the Equator and either Pole.——But one example will ſerve to illuſtrate all the reſt; for whatever appearances happen to one place, the ſame, as to kind, happen to every other place; they differing only in degree, as the Latitudes differ.——We therefore bring the pin to *London*, and rectify the poſition of the Meridian: Then will the *ſilver'd Horizon* juſtly repreſent the Horizon of *London*; and in one Revolution of the Earth round the Sun, we ſhall have all the Solar appearances, through the four ſeaſons clearly exhibited, as they really are in nature; that is, the Earth ſtanding at the firſt degree of *Libra*, the Sun then entering into *Aries*; the Meridian being turn'd to the Solar Ray, and the Hour-Index being put to XII. you will have the Earth ſtanding in its true poſition with reſpect to the Sun, as it does on the 10th of *March*, when it is noon at *London*. If I turn the handle gently, and when the Solar Ray comes to the Weſtern edge of the Horizon, the Hour-Index will point at VI. which ſhews the time of the Sun's ſetting. *London* then turning into the night, continues in darkneſs till the Hour-Index, having paſs'd over twelve hours, comes again to VI. at which time the Solar Ray gains the Eaſtern edge of the Horizon, thereby defining the time of the Sun's riſing; and ſix hours afterwards, the Solar Ray recovers the Meridian, and the Index points at XII.

thereby evidently demonſtrating the equality of Day and Night, when the Sun is in the Equinoctial. And you may alſo obſerve, that the Sun then riſes due Eaſt, and ſets due Weſt, the Solar Ray pointing all the day long exactly at the Equator drawn upon the Earth.

By turning the handle a little faſter, to haſten the annual Revolution; you will quickly obſerve, that the Solar Ray declines from the Equator towards the North, and every day at noon riſes higher upon the Gradations of the Meridian than it did the preceding day, continually approaching to *London*; the days at the ſame time growing longer and longer, and the Sun riſing and ſetting more and more towards the North, till the 10th of *June*, when the Earth arrives at the firſt degree of *Capricorn*, and the Sun appears in the Tropic of *Cancer*, riſing about 40 minutes paſt three in the morning on the North-Eaſt point of the Compaſs; and coming at noon to 23½ degrees on the Meridian, and from thence deſcending to the North-Weſt point of the Horizon, when the Sun ſets about 20 minutes paſt eight in the evening: And after continuing above ſeven hours in the Nether Hemiſphere, appears riſing again in the North-Eaſt as before. From the 10th of *June* to the 11th of *September*, the Sun recedes to the South, and the days gradually decreaſe till the Autumnal Equinox, when day and night become again equal.

From hence it appears that, during the three following months, the Sun continues to decline towards the South Pole, and the days to decreaſe till the 10th of *December*, when the Sun enters the Tropic of *Capricorn*, riſing on the South-Eaſt point of the Compaſs, about 20 minutes paſt eight in the morning; at noon coming only to the Altitude of 15 degrees, and ſetting about 40 minutes paſt three in the evening, at the South-Weſt point upon the Horizon. After which the Sun continues in the Nether Hemiſphere almoſt 17 hours, thereby ſhewing the length of the night, and then appears again in the South-Eaſt, as before. From the 10th of *December* the Sun returns towards the North, and the days continually increaſe in length, till the Vernal Equinox on the 10th of *March*; when all things are reſtor'd in the ſame order, as at the beginning.

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Thus all the varieties of the ſeaſons; the time of Sun riſing and ſetting, and at what point of the Compaſs; as alſo the Meridian Altitude, and Declination, to every day in the year; and to what place the Sun is at any time vertical; are fully exemplified and illuſtrated by this three inch Globe and its Apparatus of a Solar Ray, ſilver'd Horizon, and graduated Meridian.

To explain what is meant by a *Solar* Day and a Sydereal Day, and to ſhew their difference; I ſhall take off the Globe with its ſilver'd Horizon, and put on this Globe of the Earth, which has the circles of the Sphere and a ſketch of the countries drawn on it. By bringing it to the firſt degree of *Capricorn*, and the Meridian of *London* to the *Solar Ray*, the North Pole now ſtanding directly towards the Sun, and the Plane of the ſaid Meridian paſſing through the center of the Sun; and the Earth ſtanding diſcharg'd from its annual motion; in this ſituation, I ſay, every turn of the handle will make it roll once round, and as often the Meridian of *London* will return exactly to the point of the Solar Ray: In which caſe the Solar and Sydereal Day do not differ. But let us puſh in the ſtop which gives the Earth its annual motion; then, by one turn of the handle, the Earth will not only make one Rotation upon its Axis, but alſo be carried a little forwards in its annual Path or Orbit. By which means, the Earth's Axis always maintaining a poſition parrallel to what it was at firſt, the North Pole will be remov'd a little towards the Eaſt of the Sun; and alſo the Meridian of *London*, though it has been turn'd entirely round, will fall a little ſhort of the Solar Ray; and the handle muſt be turn'd ſomewhat more than once about, before it will be full noon at *London*, and the Plane of the Meridian will paſs through the center of the Sun. And hence ariſes the diſtinction: For the time between noon and noon conſtitutes a Solar Day; and the time in which the Earth exactly performs one Rotation on its Axis, is term'd a Sydereal Day; which, by this operation, is ſhewn to be ſomewhat leſs than a Solar Day: But as this difference is ſmall, being ſcarce four Minutes, therefore one turn of the handle hardly makes it ſufficiently apparent in the Machine; but

Aſtronomy. but by a few Turns more, it will be very viſible. For as every Sydereal Day falls near four minutes ſhort of the Solar Day, if I put the Hour-Index to XII. when the Meridian of *London* comes to the Solar Ray, and then turn the handle fifteen times about, which will finiſh 15 Sydereal Days, you may obſerve that only 14 days and 23 hours are paſſed over by the Dial, and an hour more will be required to make it noon at *London*. Thus the Solar Day is ſhewn to conſiſt of 24 hours, and the Sydereal Day only of 23 hours and 56 minutes; ſo that the Sydereal Year falls ſhort of the Solar Year by one day. And though at the beginning, the Solar and Sydereal Noons coincide, and perfectly agree, yet ſix months afterwards, it will be Sydereal Mid-night when it is Solar Noon. And this is the reaſon that the Fix'd Stars are obſerv'd to riſe, come to the Meridian, and ſet every night more early than the preceding night. For example, the *Pleiades*, or Seven Stars, are obſerv'd, in the beginning of *December*, to come due South about ten o'clock at night; a month afterwards, in the beginning of *January*, they appear on the Meridian before eight o'clock in the evening. And after this manner, all the Conſtellations of the Heavens, the whole aſſemblage of the Fix'd Stars, are apparently, with reſpect to the Sun, carried round the Heavens from Eaſt to Weſt.

Before we quit the Phænomena particularly ariſing from the motion and poſition of the Earth, I ſhall put in this Ivory Ball into the Earth's place, in ſuch a manner, as that its Axis and Poles may ſtand perpendicularly to the Plane of the Braſs Ecliptic: Which being done, the Solar Ray will continually point at the Equator of the Ivory Ball, and will never deviate in the leaſt to the North or to the South, though by turning the handle, the Ball is made to compleat a Revolution about the Sun. This ſhews that the Earth, in this poſition, would have the days and nights equal in every part of the Globe all the year long; and that the variety of the ſeaſons is entirely owing to its Axis being inclin'd to the Plane of its Orbit.

Having thus illuſtrated the Phænomena which ariſe particularly from the inclination of the Earth's Axis to the Plane of the Ecliptic, and from its rotation and revolution; I ſhall now explain to you, by this Machine before us, the Phænomena of the *Moon*, that conſtant attendant on the Earth. But, in order to this, I ſhall firſt deſcribe an Apparatus belonging to the Moon. Obſerve this ſloping Braſs Ring, one half of which is lower and the other half higher than the Earth; the two props are of the ſame height, and bear the oppoſite parts of the Ring, which reſt immediately upon them, even with the Braſs Ecliptic. The inner edge of this ſloping Ring nearly touches this artificial Moon, and repreſents the Plane of the Moon's Orbit, or Path round the Earth. The two oppoſite parts of it which lie upon the props, are call'd the *Moon's Nodes*; and as the Moon, in paſſing by the edge of this Ring round the Earth, riſes from the lower part of it to one of the *Nodes*, that is call'd the *Aſcending Node* or *Dragon's-Head*; and having paſs'd the upper part of her Orbit, ſhe falls to the other *Node*, which is call'd the *Deſcending Node* or *Dragon's-Tail*. Alſo as the Moon is ſometimes above, and ſometimes below the Plane of the Ecliptic, the diſtance which ſhe is from it, at any time, is call'd her Latitude; the greateſt diſtance, which is when ſhe is at the higheſt and loweſt points, call'd her limits, is 5 degrees and 18 minutes: And this with all the other intermediate degrees of Latitude are engrav'd upon the Ring, beginning at the *Nodes* and number'd both ways from them. Likewiſe upon the ſame Ring, without the diviſions of Latitude, a Circle is deſcrib'd, and divided into 360 degrees, or four times 90, beginning, as thoſe of the Latitude, at the *Nodes*, and in like manner, number'd both ways from them; by which the diſtance of the Moon in her Orbit from each *Node*, is found at any time by inſpection.

This ſmall Globe then repreſents the Moon, whoſe Hemiſpheres or Sides, you ſee, are diſtinguiſh'd by the one being black and the other white. This Ball is to be put into its proper place here in the Orrery, ſo as to ſtand in a line between the Earth and the Sun, with its white Side turn'd towards the Earth. Then putting the Index to XII. I ſhall unlock the annual Motion; and by turning the Handle, you may now obſerve that

Aſtronomy. the Moon moves in her Orbit round the Earth from Weſt to Eaſt: That ſhe always keeps the ſame ſide turn'd towards the Earth; and therefore it is that we never ſee any ſide of the Moon but one, as appears by the *Maculæ* or *Spots* upon her ſurface. That the Moon's Rotation upon her Axis, is made in the ſame time that ſhe takes to perform her Revolution in her Orbit round the Earth. And, if you obſerve, you will find that the Period of the Moon about the Earth is effected in 27 *Days* and 8 *Hours* nearly, call'd a Periodical Month. And to explain to you what is meant by a *Synodical Month*, and how it differs from the *Periodical Month*, I ſhall reſtore the Earth's *annual* and diſcharge its *diurnal Motion*; and by turning the handle till the Dial ſhews 27 *Days* and 8 *Hours* to have paſſed, the Moon will have finiſh'd its Revolution or *Periodical Month*. But the Earth, at the ſame time, having proceeded in its annual path above 27 *Degrees* of the *Ecliptic*, the Moon will not have got round in a direct line between the Earth and the Sun; but will require 2 days and 4 hours more to bring it again to its Conjunction with the Sun. Which ſhews that an entire Lunation, call'd a *Synodical Month*, conſiſts of 29½ days; and that the time between one *Syzygie*, or *Change*, and another, is, by means of the Earth's motion, about two days longer than it would be if the Earth ſtood ſtill.

To exhibit the ſeveral *Phaſes* or Appearances of the Moon, to an inhabitant of the Earth, I ſhall make uſe of another Ball here, which, as you may obſerve, is half black and half white, and incloſ'd within this black cap; which turns round, and alternately, either totally or partially, covers both the black and white ſides. This Ball being put into the Moon's place, in a line between the Earth and the Sun, as before, with the black cap exactly covering the white ſide, which is turn'd towards the Earth, the whole Lunar Orb will be dark; ſhewing thereby its Diſappearance, or the time of its *Conjunction* or *Change*. Now turning the handle, the Moon will be mov'd in its path about the Earth, and proceeding from its Conjunction, the black cap will begin to roll off the white ſide, and exhibit a ſmall part of it in the term of an Arch or Creſcent, as is ſeen in the New Moon, which will continually increaſe, till towards the end of the ſeventh day, from the *Change*, when you may ſee half of the Light and half of the Dark Hemiſpheres turn'd towards the Earth: This illuſtrates the appearance of the Moon at the *Firſt Quarter*. From thence the light Side will continually ſhew itſelf more and more in a *gibbous Form*; till, at the end of 14 days, the full White Side will be got from under the cap, and all the illuminated Half of the Moon will be turn'd to the Earth, and the dark Side from it; the Earth now ſtanding in a line between the Sun and Moon: And this explains the *Oppoſition* or *Full Moon*. Now again, turning the handle, the black cap will begin to hide the light Side, and the illuminated part will decreaſe in a gibbous Appearance till the *Laſt Quarter*; from whence the Moon reſumes her horns, and takes the form of a Creſcent to another *Conjunction*, where ſhe is covered with Darkneſs, as before.

By ſliding about the Earth's Plate, till the Solar Index, here, comes to the 10th of *December*; and ſetting the Lunar Orb to the poſition of *New Moon*; ſo that the Sun and Moon may be in Conjunction, they will appear both, when view'd from the Earth, to be in, or near, the Tropic of *Capricorn*. Now, turning the handle, the Moon will revolve about the Earth from the Weſt to the Eaſt, according to the order of the Signs; and in the courſe of a *Synodical Month*, you may obſerve the following particulars clearly explain'd. Firſt, That the Moon is, every night, above three quarters of an hour later in coming to the Meridian than it was the night before. Secondly, That continually from the *Change* to the *Full*, the Moon approaches towards the North, as the Sun was formerly ſhewn to do; going through as many Signs in about a fortnight, as the Sun apparently paſſes through in half a year. Thirdly, That the Moon comes to the *Full*, or *Oppoſition*, when ſhe is in, or near the Tropic of *Cancer*. Fourthly, That hence the Reaſon appears of the *Light Moons* long continuance above the Horizon in the Winter, when the Earth enjoys her benevolent reflection of the Sun's light, in that ſeaſon of the year, when the nights are longeſt, and the evenings would be leſs chearful without it.

Aſtronomy. Obſervations like the laſt being made upon the Moon, with the Earth and Sun ſtanding in due poſition at the beginning of the other three Quarters of the Year, all the reſt of the Lunar appearances, depending upon the Moon's Courſe through the *Zodiac*, are fully explain'd. And from thence appears, the great Advantage deſign'd Mankind, by the Creator of the Univerſe, in giving the Earth this faithful Attendant. For, the *Full Moon* being always in that part of the *Zodiac*, which is oppoſite to the Sun, her light ſhines upon us the longeſt, when the Sun makes his ſhorteſt appearance: But in the beginning of *Spring*, when the Days are of a moderate length, and upon the increaſe, the time of the *Full Moon's* appearance above the Horizon, is much ſhortned; and her viſible nocturnal Arch ſtill continues to leſſen as ſhe paſſes Southward to, or beyond, the Tropic of *Capricorn*, where ſhe arrives about her *laſt Quarter*. Alſo in the height of our Summer, when the Days are longeſt, and when we have little or no occaſion for the Moon's pale light, then is ſhe, at and about the *Full*, furtheſt remov'd from us, caſting her borrow'd rays copiouſly on the Southern Inhabitants, to whom it is then the depth of Winter. But, at the beginning of the Autumn Quarter, when the Sun arrives at the Equator, in his retreat from the North, and the nights begin to lengthen faſt, while yet our Harveſt is not ended, and the ripe fruits of the Earth require the attendance and labour of Man to get them timely gather'd in, then again comes the *Light Moon* to our relief; ſo that about the time that the Sun croſſes the Equinoctial in his acceſs to the North; and in our oblique Sphere for many nights after the Full, the Moon ſtill riſes before the *Crepuſculum* or Twilight ends; which accounts for the Phænomenon of what is uſually term'd the *Harveſt-Moon*; or as ſometimes it is call'd the *Hunter's-Moon*.

In order to explain the Phænomena of Eclipſes, it muſt be obſerv'd that the Sun is the only real Luminary in the Solar Syſtem; and that none of the other Planets emit Light, but are dark bodies, each of them having the Hemiſphere which is turn'd to the Sun illuminated by his Rays, which are reflected from the ſurfaces of thoſe enlighten'd Hemiſpheres. But the other ſides of these opaque Bodies are involv'd in a deep ſhadow, which is projected into the æthereal regions in the form of a Cone; which form ariſes from the luminous Body of the Sun being greater than any of the Planets: For if one of them were greater, or equal to the Sun in magnitude, then its ſhadow would be of *Infinite Length*; but proportionably as they are leſs, and placed nearer or further off the vaſt Orb of the Sun, the *Apices*, or Tops, of their conical ſhadows are at leſs or greater diſtances from them. Aſtronomy.

When the ſhadow of the Earth falls upon the Moon, it makes an *Eclipſe of the Moon*; and when the ſhadow of the Moon falls upon the Earth, it makes an *Eclipſe of the Sun*: So that an Eclipſe of the Moon never happens, but when the Earth's dark body interpoſes between the Sun and the Moon; that is at the *Oppoſition* or *Full Moon*; and an Eclipſe of the Sun never happens, but when the Moon comes into a line between the Earth and Sun; that is, at the Conjunction or Change of the Moon.

The reaſon why the primary Planets never eclipſe one another, is, becauſe their ſhadows are ſhorter, or terminate at leſs diſtance from their Orbs, than they are ſituated one from another.

If the Plane of the Moon's Orbit coincided with the Plane of the Ecliptic, there would be a total Eclipſe of the Moon every *Full*; and a Central Eclipſe of the Sun every *New Moon*. But as the path of the Moon round the Earth is oblique to the path of the Earth round the Sun, ſo there are but two points in the Moon's whole Courſe call'd the *Nodes*, which are continually ſhifting from Eaſt to Weſt in 19 years, where ſhe comes exactly into the Plane of the Ecliptic: Being every where beſides either above or below the ſaid Plane; which is the reaſon that Eclipſes happen ſo rarely. For except the Moon, at the *Full* or *Change*, is in or near one of her *Nodes*, there will be no Eclipſe. Becauſe when her Latitude, or Diſtance, from the Plane of the Ecliptic, exceeds the ſum of the apparent Semi-diameters of the Moon and Earth's ſhadow, and ſhe comes at that time to the *Full*, which is moſt generally the caſe, then, as the Axis of the Earth's ſha-

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A Spectator, on the Earth, will obſerve the Sun to move in the Ecliptic, and the Moon in her Orbit; whence it follows that the Sun and Moon can never be ſeen in a right line from the Center of the Earth, but when the Moon is in one of her *Nodes*; and then only will the Sun appear centrally eclipſed. But if the conjunction of the Moon happens when ſhe is within a certain diſtance of the *Nodes*, either North or South, then the Sun will be eclipſed more or leſs, according to the diſtance from the *Nodes*: At one diſtance, the Sun will be one half eclipſed; at another the Moon's limb will juſt touch the Sun's diſk, without hiding any part of it. The Earth's Shadow, at the place where the Moon's Orbit interſects it, is three times as large as the Moon's Diameter; and therefore it often happens that Eclipſes of the Moon are total, when they are not central. For the ſame Reaſon the Moon may ſometimes be totally eclipſed for three hours together; whereas total Eclipſes of the Sun can ſcarcely ever exceed four minutes.

By putting this Lamp, ſmall Earth, and Moon in their proper places, and darkening the Room, you will ſee that when the conjunction of the Moon happens; if then ſhe is in or near one of her *Nodes*, her ſhadow will fall on the Earth, and ſo deprive that part, upon which it falls, of the light of the Sun. If the conjunction happens when the Moon is not near one of her *Nodes*, the light of the lamp will fall upon the Earth, either above or below the Moon, according to her Latitude at that time. In like manner, when the *Full Moon* happens near one of her *Nodes*, the ſhadow of the Earth will fall upon the Moon; and, if the Moon's Latitude be but ſmall, her whole face will be involv'd in darkneſs. At other times, when the Full Moon happens when ſhe is not near one of her *Nodes*, the ſhadow of the Earth will

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paſs, either above or below the Moon; and ſo eſcape being eclipſed.

This little Globe is the repreſentative of *Venus*. By turning the handle you may, by the Dial, obſerve this Planet moving upon its Axis in 24 days; and at the ſame time carried forwards in its Orbit round the Sun, and compleats its Revolution in 224 days and 16 hours. To explain the other appearances of *Venus*, here are two ſmall Wire Indexes, one of which is laid over the Earth and *Venus*, and the other over the Sun and *Venus*. The firſt of theſe Rods points out the place of the Ecliptic, which *Venus* appears to be in, as beheld from the Earth, which is call'd its *Geocentric Place:* And the other ſhews when it appears in the Ecliptic, as beheld from the Sun, which is call'd its *Heliocentric Place*. Now turning the handle about, the Geocentric and Heliocentric motions of *Venus* will be clearly explain'd by the Wire Indexes, which are faſten'd to the Sun and Planets by ſmall ſliding pins. This Wire, which lies over the Earth and *Venus*, ſhews how that Planet appears to us ſometimes to go forwards, ſometimes backwards, and at other times to ſtand ſtill amongſt the Fix'd Stars; though really it always proceeds regularly from Weſt to Eaſt in its path round the Sun. Next, I ſhall explain what is call'd the *Elongation of Venus*, by this *double Index*, opening like a pair of Compaſſes, with a graduated Braſs Arch: The center of this Index being placed over the center of the Earth by a pin, and one leg ſtretch'd over the Sun, and the other over *Venus*, and kept there by two moveable pins; then the handle being turn'd about, *Venus* will be mov'd forwards in its Orbit, and thereby the legs of the Index will be open'd or clos'd, ſhewing the decreaſe and increaſe of the Planets Elongation, by an intercepted part of this Arch, which will be ſeen never to exceed 48 degrees from the Sun, when receiv'd from the Earth.

The Planet *Mercury* being put into its proper place, between the Sun and *Venus*, all its appearances are ſhewn in the ſame manner as thoſe of *Venus*; that is, its *Period* or Revolution round the Sun in 88 days nearly; its *Geocentric* and *Heliocentric Places*; its

Aſtronomy. *Stationary*, *Progreſſive*, and *Retrograde* Motion in its courſe through the Ecliptic; and its *Elongation*, which at greateſt is but 28 degrees. This Planet has not yet been diſcover'd to revolve about its Axis, and therefore the Orrery does not give it that Motion.

After the ſame manner as the appearances of the two inferior Planets have been explain'd, in the ſame way the Phænomena of the three ſuperior planets are explain'd, by putting on, firſt *Mars*, which revolves upon its Axis in 24 hours and 40 minutes, and about the Sun in 687 days nearly; then *Jupiter*, which turns on its Axis in 9 hours and 56 minutes, and finiſhes his long period round the Sun in 12 years or thereabouts: And laſtly *Saturn*, the moſt remote from the Sun of all the known primary Planets: Its Revolution upon its Axis is not diſcover'd, but it performs its tedious journey round the Sun in about 29½ years. The Revolutions and Periods of *Mars*, *Jupiter*, and *Saturn*, being thus explain'd, their Geocentric and Heliocentric places, with their apparent Progreſſions, Stations, and Retrogradations are exhibited by the ſame *Wire-Apparatus*, and in the ſame manner as thoſe of *Venus* and *Mercury*.

Theſe four ſmall Balls are the repreſentatives of the Moons, which are diſcover'd to revolve about *Jupiter*; and theſe five repreſent the Moons of *Saturn*. Theſe being placed in the Orrery, the various *Motions*, *Periods*, *Tranſits*, and *Eclipſes* of theſe *Secondary* Planets, or Moons, are explain'd after the ſame manner as the *Phænomena* of the Moon, which attends our Earth, were.

This little Apparatus repreſents that wonderful Ring which is obſerv'd to ſurround *Saturn*, at ſome diſtance from its body. By ſliding the plate of *Saturn* about, you may ſee the various *Phaſes* of his Ring, as beheld from the Earth. For though the Ring is abſolutely circular, yet, from its poſition, it can never appear to a Spectator upon the Earth, more than an Ellipſis, whoſe greateſt Diameter is double its leaſt. As the poſition of the Ring maintains a paralleliſm through the whole Revolution of *Saturn*, ſo it will ſeem to vary its form perpetually; now growing broader, then again narrower, and ſometimes almoſt diſappearing, the edge of it being turn'd towards the Earth, and no more of it is ſeen but the two extreme parts, looking like *Anſæ*, or handles, to the Orb of *Saturn*.

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Having thus explain'd to you the various *Phænomena* of the Sun and the Planets, primary and ſecondary; I ſhall now exhibit the whole ſyſtem together. And as I have adjuſted the whole to this particular time by this *Ephemerides*, or Journal of the Heavens, and regulated the Dial to this ſame time; now by turning the handle, you will have at one view the whole operation of the Planetary Syſtem, and all the various Changes and *Phænomena* therein, regularly carried on in the Orrery, as they really are at this preſent time in Nature.

And to give you a general idea of the Motions of *Comets*, this *gilt Wire*, the ends of which being ſcrew'd into theſe circles of the Armillary Sphere, deſcending into the Orrery to a ſmall diſtance beyond the Sun, repreſents the lower part of the *Trajectory* or *Path* of a *Comet*. This gilt Ball being let go from this circle of the Sphere, will deſcend along the *gilt Wire*; thereby ſhewing the Motion of a *Comet* in its Orbit; and its coming to its *Perihelion*, or neareſt approach to the Sun.

And now, to compleat all, here is a Lamp, which I ſhall put into the place of the Sun, and make the room dark, ſo that no Light may appear but that which the Lamp gives through the Convex Glaſs; by means of which it will more ſtrongly illuminate the Planets. Now, turning the handle, you will have an exact and beautiful repreſentation of the whole Planetary Syſtem. You may, with gratitude and wonder, behold moſt naturally exhibited, the Phænomena of the *Seaſons*, the Increaſe, Decreaſe, and Lengths of Days and Nights throughout the year; the various *Phaſes* of both Primary and Secondary Planets; and all the *Eclipſes*, *Tranſits*, and other appearances and changes, depending on the *Illumination* of the Sun, that have hitherto been diſcover'd by Aſtronomers.

CHAP. IV.

The Aſtronomical Principles of CHRONOLOGY.

Chronology. IN order to give you a clear idea of this *important Branch of Education*, I ſhall conſider it according to the following Analyſis: And to make theſe Aſtronomical Principles of Chronology, ſtill more eaſy and entertaining to you, I ſhall explain every particular, when it can poſſibly be done, by the Orrery, and by an Apparatus adapted to that purpoſe.

To meaſure out our days and years exactly, we ſhould have recourſe to ſomething which is, in its own nature, always of one and the ſame tenor. For this purpoſe, we have nothing ſo convenient as the motions of the Heavenly Bodies; and among theſe motions, none are ſo obvious to us, as thoſe of the Sun and Moon; which therefore have been agreed upon, by the conſent of all Nations, for that great end.

Firſt, The Aſtronomical Principles of Chronology, which I ſhall ſubdivide as follows;

I. Solar Year, which is divided into
  1. Tropical Year.
  2. Periodical Year.
  3. Civil Year, which is
    1. Common Year.
    2. Biſſextile Year.

II. A Day, which is divided into
  1. Solar.
  2. Sidereal.

III. Hours, which are divided into
  1. Equal Hours.
  2. Unequal Hours.

Having proceeded thus far, I ſhall ſhew you how Time is naturally divided into true Time and apparent Time, and explain the Equation of Time to you; and then proceed to conſider,

IV. A Month, which is either
  1. A Solar Month, or
  2. A Lunar Month, which is divided into

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        1. Periodical Lunar Month.
        2. Synodical Lunar Month.
        3. Illuminative Lunar Month.
    3. Civil Month or Kalendar Month, divided into
        1. Civil Solar Month.
        2. Civil Lunar Month.
V. The Lunar Year, divided into
    1. The Aſtronomical Lunar Year.
    2. The Civil Lunar Year, divided into
        1. Common Civil Lunar Year.
        2. Intercalary or Emboliſmic.
VI. A Week.

Secondly, The Conſtruction of the Kalendar, with the nature and uſe of the Cycle of the Sun, Moon, Indiction and Julian Period.

Thirdly, The ways of Reckoning among different People from their particular diviſion of Time, deduced from the motions and appearances of the Heavenly Bodies.

Fourthly, The application of Chronology to the moſt remarkable Epocha's.
    1. Sacred.
    2. Prophane.

Laſtly, The Principles of Chronology, concluded with ſome Lectures on the moſt remarkable events in hiſtory.

Of all theſe in their order.

Firſt, To underſtand the Tropical Year, you muſt know what is meant by the *Preceſſion of the Equinoxes*, or more properly the *Retrogreſſion of the Earth's Nodes*. The cauſe of this *third* motion of the Earth's Axis was unknown to all the Aſtronomers and Philoſophers, before Sir *Iſaac Newton*'s time; none of them being able to gueſs, from whence it could proceed: But that great Man inveſtigated the cauſe of this ſlow apparent alteration of the poſition of the Fix'd Stars, which is occaſion'd by the receſſion of the Equinoctial Points: He demonſtrated it to reſult from the laws of Motion and Gravity, which ſhall be ſhewn, when you are duly

Chronology. prepar'd for theſe matters. From this motion of the Earth's Axis, all the Conſtellations continually appear to change their places; for the Bright Star in *Aries*, which, in *Hipparchus*'s time was near the vernal Equinox, is now remov'd near a whole Sign, or 30 degrees Eaſtward, and is in the beginning of *Taurus*; and *Taurus* is got into *Gemini*, *&c.*

The ſeveral Points of the Ecliptic having this Retrograde Motion, you may eaſily underſtand, by this Machine before us, that this Receſſion of the Equinox will, as it were, meet the Earth; and cauſe, that the Earth ſhall arrive at the Equinox before it has compleated its Revolution; and this is call'd the Tropical Year. But,

Secondly, If this firſt Point, or beginning of *Aries*, were fix'd, each annual Revolution would be conſtantly of the ſame duration; and therefore ſuch a motion would be an equal meaſure of the year, which is call'd a *Periodical Year*; as being the time of the Earth's Period about the Sun, conſiſting of 365 days 6 hours 9 minutes and 14 ſeconds; for ſo long is the Earth before it returns to any fix'd Point in the Heavens from whence it departed. But the *Tropical Year* cannot be ſo long, becauſe the firſt Point in *Aries*, as ſoon as the Earth has departed from it, keeps moving, in appearance, the contrary way, ſo as to meet it, as it were, when it has nearly finiſh'd its courſe. And this Tropical Motion is found to be perform'd in 365 days, 5 hours, 48 minutes, 57 ſeconds; which falls ſhort of the Periodical Year by 20 minutes and 17 ſeconds.

Thirdly, The *Civil Year* is that form of year, by which each Nation has contriv'd to compute Time; or the *Civil* is the *Tropical Year* conſider'd as only conſiſting of 365 days; the odd hours, minutes and ſeconds being ſet aſide, to render the computation of time, in the common occaſions of life, more eaſy. Hence as it is neceſſary to keep pace with the Heavens, it is requir'd that every fourth year conſiſt of 366 days; which makes the Civil Year to be either *Common*, or *Biſſextile*.

1. The *Common Civil Year* is that conſiſting of 365 days. And, Chronology.

2. The *Biſſextile* or *Leap Year*, that of 366 days, or which has a day extraordinary; which day is call'd *Intercalary* or *Biſſextile* Day. *Julius Cæſar*, to make the *Civil Year* keep place with the *Tropical Year*, was the firſt who appointed this *Intercalary Day*; by contriving that the ſix hours, which the former came ſhort of the latter, ſhould in four years make a whole day, and be added to the 24th of *February*. Therefore, on that year, they reckon'd this day twice over; and as it happen'd on their ſixth of the *Calends* of *March*, according to their manner of reckoning, the year itſelf came to be call'd *Biſſextus* or *Biſſextile*. The *Intercalary Day*, however, among us, is not put in by telling the 24th of *February* twice over; but by adding a day after the 28th of *February*; which month, in that year, thereby comes to contain 29 days.

But the ſix hours added by *Julius Cæſar* is too much; for the Sun finiſhes his Courſe in the Ecliptic in 365 days, 5 hours, 48 minutes, and 57 ſeconds; and therefore begins again his round 11 minutes, and 3 ſeconds, before the *Civil* or *Julian* Year is ended, which in about 131 years amount to one whole day; and therefore the Equinox will not always fall upon the ſame day of the month; but by degrees it will move towards the beginning of the year. Thus, at the *Council of Nice*, in the year 325, when *Eaſter* was fix'd, the Vernal Equinox fell upon the 21ſt of *March*; and the Equinox continually falling backwards in the year, occaſion'd, from its anticipation, the variation of a whole day, in the courſe of about 131 years; ſo that when the Calendar was corrected in the year 1582, it was found that the Sun enter'd the *Equinoctial Circle* on the 11th of *March*, and was departed ten whole days from its former place in the year. And ſince the *Council of Nice* to the preſent year 1749, there have elapſed 1424 years; by which means the Equinox, at this time, falls on the 10th of *March*, which is 11 days later than it happen'd in the year 325.

Pope *Gregory* XIII. corrected, as he thought, the Calendar in 1582, by placing the Equinox in its for-

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Hence then, if three days are omitted at the end of every 391 years, the Equinox will very nearly keep to the ſame day of the month, in ſucceeding ages.

If we compare the *Periodical Year* with the *Common Civil Year*, the 6 hours added are too little; for the Sun will not have finiſh'd his courſe by 9 minutes, 14 ſeconds, when the *Civil Year* is ended: And this difference, in 156 years, amounts to a whole day; and therefore the Equinox will, by degrees, move towards the Summer-Seaſon, the contrary way to what it does, when we proceed upon the difference between the *Tropical* and *Common Civil Year*.

I come now, ſecondly, to explain that part of time we call a Day, which is divided into *Solar* and *Sidereal*.

1. The *Solar Day* is that ſpace of time which intervenes between the Sun's departing from any one Meridian, and its return to the ſame Circle again; which ſpace is alſo call'd a natural Day; or it is the time from the noon of one day to the noon of the next day.

2. The *Sidereal Day* is the ſpace of time, which happens between the departure of a Star from, and its return to, the ſame Meridian again.

3. Each

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3. Each of theſe *Days* are divided into 24 parts, call'd *Hours*; each hour divided into 60 minutes, each minute into 60 ſeconds, each ſecond into 60 thirds, *&c.* Theſe hours, by Aſtronomers, Chronologers and Dialiſts, are divided into, 1. *Equal*; and 2. *Unequal Hours.* Becauſe the diurnal Motion of the Earth about its Axis is equable, every Revolution will be perform'd in the ſame time, and therefore all the *Sidereal Days*, and hours of thoſe days, will be *equal.* And on the other hand, the *Solar Days* and hours are all *unequal:* For if the Earth had no other motion but that round its own Axis, all the days would be exactly equal to one another, and to the time of the Revolution round the Axis. But becauſe while the Earth is performing its diurnal Revolution, it is alſo moving Eaſtward round the Sun; when any Meridian has compleated its Revolution, aſter having paſs'd the Center of the Sun, its Plane will not have again paſs'd through the Sun, as you may perceive by this Scheme and Machine before us. Let S be the Sun, A B the Ecliptic, A the Center of the Earth, and M D a Meridian whoſe Plane paſſes through the Center of the Sun. In the time of one diurnal Revolution, let the Earth be carried in its Orbit from A to B; and then the Meridian M D will be in the poſition *m d*, parallel to its former poſition. But the Meridian *m d* is not yet directed to the Center of the Sun, nor will not, till, by its motion, it comes into the ſituation *e f*: Whence it is evident, that all the *Solar Days* are longer than the *Sidereal Day.*

But, beſides this, the Earth's Orbit is an Ellipſis, and therefore her *annual* Motion cannot be *equable:* For in its *Aphelion* it deſcribes a leſs Arch, in its *Perihelion* a greater, if the times be equal; and as the time of the motion d B f, which, beſides the entire Revolution, is to be added to the ſpace of a *Solar Day* to compleat it, is not always of the ſame quantity; whence the *Solar Days* will not be *equal*, but are always *variable.* Since therefore the *apparent* Motion of the Sun from Eaſt to Weſt is *unequal*, it cannot be a fit meaſure of time, which ſhould always go on at the ſame rate. Hence Aſtronomers have been oblig'd, inſtead of theſe *Solar Days*, to ſubſtitute other days that were *equal*, and a proper mean

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between thoſe irregular days; and this *equated Time*, is again converted into *apparent Time*, that theſe motions may be obſerv'd by us, who meaſure our *Times* by the *apparent* motion of the Sun.

IF we ſuppoſe a Star to move in the Equator Eaſtward, and which never quickens or ſlackens his pace, but goes through that Circle in preciſely the ſame time as the Sun ſpends in his annual Revolution; this motion will repreſent *Equal Time*, and its diurnal motion in the Equator will be daily 59 minutes and 8 ſeconds, the ſame as the *Mean Motion* of the Sun in the Ecliptic. And ſince the Sun goes unequally Eaſtward, according to the Equator, ſometimes it will come to the Meridian ſooner than this imaginary Star, and ſometimes later; now this difference is that which is between the *true* and *apparent Time*. And this difference is known by having the place of the imaginary Star in the Equator, and that point of it, which comes to the Meridian with the Sun; for the Arch, here in this Machine, intercepted between them, being converted into *Time*, ſhews the difference between *equal* and *apparent Time*, which is call'd the *Equation of Time*.

From what has been ſaid, it appears, that, as there is no *natural* Body, which can by its motion meaſure Time *truly*, the only way to do this is, by the *artificial* Contrivance of Clocks, Watches, *&c.* But then the *apparent* Time ſhewn by the Sun, or by a *Sun-Dial*, is but four days, in the whole year, the ſame with the *mean* or equal time ſhewn by a good Clock or Watch; that is, about the 4th of *April*, *June* 6th, *Auguſt* the 20th, and *December* the 13th. Alſo about the 23d of *October* the *Equation* is greateſt of all in the year, being about 16 minutes and 11 ſeconds; *Clocks* being then ſo much ſlower than *Sun-Dials*.

The *Artificial Day* is the ſtay of the Sun above the Horizon; and theſe days are divided into twelve parts or hours, which muſt be alſo *unequal Hours*, becauſe at different ſeaſons of the year, the days are of *unequal Lengths*; except on the Equinoctial days, when the days and nights are equal to each other: And then theſe days are equal to the Solar days: Thus then as an

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an artificial day is divided into twelve parts, ſo its artificial night, in oppoſition to it, is alſo divided into twelve parts, which muſt alſo be different as the nights have their different lengths, at different ſeaſons of the year, except on the Equinoctial days; ariſing from the obliquity of the Sphere, or as places are more or leſs remov'd from the Equator. Hence alſo theſe *artificial* hours are divided into equal and unequal: *Equal* or *Equinoctial* hours, becauſe on the Equinoxes the hours of thoſe days are equal to the hours of the nights: And unequal hours for the reaſons abovemention'd.

IV. We come now to that part of time call'd a *Month*, becauſe it is the time of the Moon's Revolution about the Earth, and is alſo call'd a *Lunation*. But a Month is alſo divided into *Solar*, *Lunar*, and *Civil Months*.

1. The Solar Month is the ſpace of time, wherein the Sun moves through one entire Sign of the Ecliptic: Hence, if regard be had to the Sun's true motion in his annual Revolution, the *Solar Months* will be unequal; ſince he is longer in paſſing through the Winter Signs than thoſe of the Summer: But as he conſtantly travels through all the Twelve Signs in 365 days, 5 hours, 48 minutes, and 57 ſeconds, the quantity of a *Mean Month* will be 30 days, 10 hours, and near 30 minutes.

2. The *Lunar Month* is divided into *Periodical*, *Synodical*, and *Illuminative*.

If we reſpect the Revolution of the Moon, from any fix'd Point in the Heavens, ſuppoſe a Star, to the ſame again; this is call'd a *Periodical Month*, and conſiſts of 27 days, 7 hours, and 43 minutes. But,

On the contrary, while the Earth is getting forward in her annual Revolution; and the Moon is performing one of her *Lunations*, the Earth will have gone by near a whole Sign: And the time that paſſes between one *Conjunction* or *New Moon*, and the next following, is call'd a *Synodical Month*, and is equal to 29 days, 12 hours, 44 minutes, and 3 ſeconds: So that the Point of the Orbit, which in the former poſition was plac'd

Chronology. in a Right Line joining the Centers of the Earth and Sun, will not yet in the ſecond poſition be ſeen in conjunction to the Sun, when the Moon has again arriv'd at that Point. For let the Moon be in Conjunction L, in the Scheme before us, and when the Earth T arrives at t, by the lines L T and l t being parallel, though the Moon has deſcrib'd her Orbit, and is arriv'd at l, yet ſhe muſt move to M before ſhe comes in Conjunction to the Sun; therefore her Periodical Motion, added to the Angle l t M, gives her Synodical Month.

The *Illuminative Lunar Month* is the ſpace from the firſt time of her appearance after New Moon, to her firſt appearance after the New Moon following: Hence, as the Moon appears ſometimes ſooner after the New Moon, and ſometimes later, the quantity of the Illuminative Month is not always the ſame.

3. The Civil Month conſiſts of a certain number of days, fewer or more, according to the laws of the Kingdom or State in which they are obſerv'd; and theſe days approach nearly to the quantity of either Solar or Lunar Months.

A *Civil* or *Calendar Month* is divided into a *Civil Solar Month* and a *Civil Lunar Month*.

The *Civil Solar Months* are to conſiſt alternately of 30 and 31 days; excepting one month of the 12, which for every fourth year ſhould conſiſt of 29 days, and the other three of 28.

The *Civil Lunar Months* are to conſiſt alternately of 29 and 30 days; then will the New Moon be kept to the firſt day of ſuch *Civil Lunar Month*, for a long time together: However, in order to allow for the odd minutes, and to make them keep pace with the *Civil Solar Months*, at the end of each 948 months, a month of 29 days muſt be added; or elſe the thirty-third month muſt conſiſt of 30 days.

V. The *Lunar Year* is a ſyſtem of 12 Lunar Months; and from this *Lunar Year* ariſes the *Aſtronomical Lunar Year* and the *Civil Lunar Year*.

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1. The Aſtronomical Lunar Year conſiſts of 12 *Lunar Synodical Months*; and therefore contains 354 days, 8 hours, 48 minutes, 38 ſeconds, and 12 thirds.

2. The *Civil Lunar Year* is either *Common* or *Intercalary*.

The *Common Civil Lunar Year* conſiſts of 12 Lunar Civil Months; and therefore contains 354 days.

The *Intercalary* or Emboliſmic conſiſts of 13 Lunar Civil Months.

Now to equate the *Civil Lunar* to the *Civil Solar Year*, 11 days are to be added, call'd by us *Epacts*. This Civil Lunar Year, being leſs than the Civil Solar Year, brings back all the ſeaſons by 11 days; and therefore the beginnings of ſuch years move through all the ſeaſons, and that in the ſpace of 32 years. Since then twelve *Lunations* are leſs than a Civil Solar Year by eleven days, three Lunar Years are leſs than three Solar Years, by 33 days; and therefore to keep the months in the ſame ſeaſons and times of the Solar Year, to the third year there is a whole month added, and it conſiſts of 13 months: And this is done as often as is needful, to keep the beginning of the year always in the ſame ſeaſon; and the month added is call'd an *Intercalary Month*.

VI. The laſt part of time I ſhall mention is a Week; which is a ſyſtem of ſeven days. Becauſe the Antients ſuppos'd the Seven Planets had an influence upon the Earth and all terreſtrial things, they alloted the firſt hour of each day to the Planet they then ſuppos'd to preſide; from whence the ſeveral days of the week receiv'd their names. The diviſion of Time into ſevenths appears to have been us'd from all Antiquity, and the Seventh Day was in extraordinary veneration. The Seventh Day was call'd *Dies Saturni*, or *Saturday*; to this day ſucceeded *Dies Solis*, or *Sunday*, which is the firſt day of the diviſion; then *Dies Lunæ*, or *Monday*; *Dies Martis*, or the day of *Mars*, *Tuiſco Tueſday*; *Dies Mercurii*, the day of *Mercury*, *Wooden Wedneſday*; *Dies Jovis*, the day of *Jupiter*, *Thor*

Chronology. *Thurſday*; *Dies Veneris*, the day of *Venus*, *Frigo Friday*.

I come now to the Conſtruction of the Calendar; which is the Second general Diviſion of the Analyſis. Beſides the meaſure of time by years, months, weeks and days, it became neceſſary to introduce the uſe of *Cycles*, that is *Circles* of years; as the Cycle of the Sun, the Metonic Cycle, the Cycle of Indiction, and the Julian Period compounded of all the reſt. The uſes of which are as follow.

The Cycle of the Sun ariſes from the number 365 being divided by 7, the days in the week, which leaves 1; and ſhews that the laſt day of the year is the ſame day of the week with the firſt day of the year. Now it was always cuſtomary to place againſt the ſeven days of the week, the ſeven firſt letters of the alphabet, A, B, C, D, E, F, G; and therefore as they were continu'd through the year, it is evident the ſame letter muſt ſtand againſt the firſt and laſt day of the year, *viz.* the letter A. Hence, if the firſt of *January* be a *Sunday*, the letter A will point out all the *Sundays* in *that* year: And ſince the firſt of *January* in the next year is *Monday*, the firſt *Sunday* will be on the 7th day; againſt which ſtands the letter G, which therefore will be a *Sunday* letter for all that year. The firſt day of the following year being *Tueſday*, the firſt *Sunday* will be on the 6th, againſt which ſtands the letter F; which therefore indicates the *Sundays* throughout the year; and ſo on. Whence it is eaſy to obſerve, that the letters, which point out the *Sundays* in every year, will be in a retrograde order; that is, A, G, F, E, *&c.* And becauſe theſe letters ſhew the *Dies Domini*, or the Lord's Day, they are call'd *Dominical Letters.* Now, if each year conſiſted of only 365 days, the ſame letter would not be the *Dominical Letter* again, till after a Cycle or Revolution of ſeven years: But ſince every fourth year has a day extraordinary, this day will interrupt the ſucceſſion of the Dominical Letters, and cauſe that the ſame days will not be ſhewn again, by the ſame letters, after a Cycle of ſeven years, but of 4 times 7, or 28 years. Hence, if the common year begins on *Sunday*, the beginning of the following year ſhould fall

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on a *Monday*; but if *that* following year be Biſſextile, the beginning of that year will fall on a *Tueſday*: For the Common year is 52 weeks and 1 day, and the Biſſextile 52 weeks and 2 days; and conſequently if that year ſhould begin on a *Sunday*, it will end on *Monday*, as the Common Years have the firſt and laſt days the ſame. The Cycle of the Sun being compleated, the days of the months return, in the ſame order, to the ſame days of the week. Now, becauſe from the time of the Julian Correction there is an Intercalation every fourth year, the letters cannot fall into the ſame order before the Biſſextile has affected every letter, which it cannot do till the Period of 28 years, or 7 times 4 years, has elapſed.

In the Biſſextile there are two Dominical Letters, the firſt letter ſerving from the firſt of *January* to the end of *February*; and then the ſupernumerary day coming into the Calendar, makes an alteration in the Dominical Letter; the latter Dominical Letter ſerving to the end of *December*.

The firſt year of the Solar Cycle being a Biſſextile, as it was appointed by *Julius Cæſar* that year, when he corrected the Calendar; and the letters, from the remainder I, running retrograde; we may form a Table of theſe Dominical Letters, and by that means ſhew, what letter or letters belong to each year of the Cycle.

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A TABLE

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A TABLE, *ſhewing the* Dominical LETTER *or* LETTERS, *for every Year, of the* Cycle *of the* SUN.

Cycle of the Sun	Dominical Letters	Cycle of the Sun	Dominical Letters
1	GF	15	C
2	E	16	B
3	D	17	AG
4	C	18	F
5	BA	19	E
6	G	20	D
7	F	21	CB
8	E	22	A
9	DC	23	G
10	B	24	F
11	A	25	ED
12	G	26	C
13	FE	27	B
14	D	28	A

Now from this Table, you may find the Cycle of the Sun for any year of Chriſt: For there being 28 years in this Cycle; and from *Julius Cæſar*'s Correction to the firſt year of Chriſt being 9 years; therefore that number being added to the preſent year of Chriſt, 1749, makes 1758 years: And there being 28 in a Cycle, 1758, divided by that number, ſhews there have been 62 Cycles; and the remainder 22 is the current year of the Cycle, which points out the letter A.

The *Metonic Cycle*, from *Meton* its Author, otherwiſe call'd the *Cycle of the Moon*, is a Revolution of 19 years; after which time, as was antiently ſuppos'd,

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the New and Full Moons would fall upon the ſame days of the year again. This Cycle is of great note in the Chriſtian Church; being eſtabliſh'd by the Fathers of the *Nicene Council*, for finding the time of celebrating *Eaſter*, and the other moveable Feaſts of the Church, for any time to come.

In order to underſtand this Cycle, you muſt know that the *Jewiſh* Months being Lunar ones, each Month began upon the day of the New Moon, and by that means the Full Moon fell upon the fourteenth day of each Month; and that Month was the firſt in their Year, whoſe fourteenth day, either fell upon the vernal Equinox, or was the firſt that ſucceeded it.

The *Jews*, to make their Lunar Months conformable to a Solar Year, were oblig'd every two or three Years to intercalate a Month and have 13 Months in their Year. The principal thing they agreed on, was, the dependence of their firſt Month upon the vernal Equinox, or the Sun's entrance into the firſt Degree of *Aries*; and particularly, that the 15th day of that Month ſhould be always after it. Now the *Jewiſh Paſſover*, at its firſt inſtitution, was appointed to be kept on the 14th day of the firſt Month, according to their manner of reckoning: And our Saviour being crucified on Friday, at the *Jewiſh Paſſover*, he roſe again on the Sunday following. The Chriſtians, in order to keep up the memory of ſo great a Deliverance, by a ſolemn Feſtival, call'd theirs alſo the Paſſover; and had no other rules for the finding of it, but what the *Jews* had for theirs, and left the Calculation of it to them. Accordingly the rule, for finding *Eaſter*, was drawn up at the time of the *Nicene* Council; the Equinox then falling, or was thought to fall, on the 21ſt of *March*. But, becauſe the Reſurrection happen'd on a Sunday, it was order'd that it ſhould not be kept on the Full Moon, but the Sunday following. The rule ſtill made uſe of by the Church, is, *That Eaſter-Day is always the firſt Sunday after the firſt Full Moon, which happens next after the 21ſt of* March; *and if the Full Moon happens on Sunday, Eaſter-Day is the Sunday after.* If the Solar and Lunar Year began together at any time, theſe Years being to each other as

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365 to 354 would not coincide again, at their beginning, till after a certain time, *viz.* 235 Lunations, which make 6939 Days, 16 Hours, 31 Minutes, 45 Seconds; and in 19 Solar Years are 6939 Days, 18 Hours; the difference being only 1 Hour, 28 Minutes, 15 Seconds, ſhews the two Years will then begin again very nearly at the ſame time, and the New and Full Moons come round again upon the ſame Days of the Month. And this deficiency of an Hour and half, will cauſe the New and Full Moons to happen ſo much ſooner, each Cycle in the Heavens, than by this reckoning; and this, in 304 Years, amounts to a whole Day: And therefore at this time they happen almoſt five Days ſooner than they ſhould do, by the rule ſettled by the *Nicene* Council, for finding the ſame by the *Golden Numbers*; the nature and uſe of which I come now to explain.

It is to be obſerved, that in order to find on what Days of the Year the New and Full Moons would happen for the time to come, the antient method was to obſerve on what Day of each Month, the New Moons fell in each Year of the Moon's Cycle: To theſe Days reſpectively they ſet the Number of the Year in their Calendar. Thus, obſerving that the New Moons, in the firſt Year of the Cycle, fall on *January* the 23d, *February* 21ſt, *March* 23d, *&c.* to thoſe Days they affix'd the Number 1. And in like manner obſerving, that, in the ſecond Year, they fell on *January* 12th, *February* 10th, *March* 12th, *&c.* to each of them they put the Number 2. and ſo for each Year of the Cycle. And, on account of their great Uſefulneſs, or becauſe they were wrote in letters of Gold, the Number thus ſet to the Days on which the New Moons fell, were call'd *Golden Numbers:* Tho' in the Table for finding *Eaſter* for ever, in ſome *Common Prayer* Books, they are call'd *prime Numbers*, probably as being placed in the prime or firſt column of the Calendar.

In order to find by ſuch a Calendar when the New Moons happen, it is only looking for the Golden Number of any Year, and over againſt it ſtands the Day in each Month in that Year, in which the New Moon

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Moon happens. But by the Full Moon thus found is meant the time of the Full Moon retain'd in the Church, and not by Aſtronomical Obſervation. Not but the true Full Moon may be found by the Calendar, if we deduct 5 Days in conſideration of the deficiency in the Moon's Cycle; as the New Moon falls 5 Days ſooner than that method ſhews it to do.

The *Cycle of Indiction*, conſiſting of 15 Years, was ſo call'd, becauſe the Numbers of this Cycle were to indicate ſome particular Period; but upon what account this Cycle was inſtituted is undetermin'd: However it was made uſe of, both by the *Greeks* and *Romans*, probably upon ſome political account. The Nativity of our Saviour fell upon the 4th of this Cycle.

The origin of Cycles was this: The apparent revolution of the Sun round the Earth has been divided arbitrarily into 24 parts or hours, the baſis of all our menſuration of time. But as neither the annual Motion of the Sun, nor that of the other Heavenly Bodies, can be meaſur'd exactly without a remainder; ſo to ſwallow up theſe Fractions in whole Numbers, and yet in Numbers which only expreſs Days and Years, Cycles have been invented; which comprehending ſeveral revolutions of the ſame Body, replace it, after a certain Number of Years, in the ſame point of the Heavens, whence it firſt departed; or, which is the ſame thing, in the ſame place of the *Calendar*.

Of the three *Cycles*, the *Solar*, *Lunar*, and of *Indiction*, already explain'd, was form'd that famous *Period* commonly call'd the *Julian Period*. For if you carry the Solar Cycle 28 into the Lunar Cycle 19, the product will be 532, which is the *Victorian Period*, afterwards made uſe of by *Dionyſius*, to regulate the Celebration of *Eaſter*; and this Period was afterwards receiv'd, till the Reformation made under Pope *Gregory* XIII. If the *Dionyſian Period*, 532, be again carried into the *Cycle of Indiction* 15, that product will be 7980, call'd the *Julian Period*. Now if this Number be divided by 28, 19, and 15, there will be no remainder after the diviſion. This Period has this pe-

Chronology. culiar to itſelf, that within 7980 Years there cannot be found two Years which will chance to have theſe three Cycles alike. As theſe Cycles were not known before the Birth of Chriſt, it appears, that the *Julian Period* has not produc'd thoſe ſignal advantages, which otherwiſe could have been expected from it. It has, however, this great one, of being the common meaſure of time, the leaſt controverted which can be made uſe of by *Chronologers*; which may be ſhewn thus. Though they all agree in the enumeration of the ſubſequent Years ſince Chriſt; yet there is a diſagreement among them, with reſpect to the time from the Creation of the World to the Chriſtian *Æra*. Therefore it was very natural to endeavour to find out a Period, which, being confin'd to no circumſtances, would be adapted to every Hypotheſis or Syſtem of *Chronologers*: However, it appears by retrograde Numeration that the 10th Year of the Solar Cycle, the 2d of the Lunar, and the 4th of the Indiction, are to be attributed to the 1ſt Year of the Chriſtian *Æra*. Therefore, if in the *Julian Period* of 7980 Years, we deſire to know to which the Solar Cycle 10, the Golden Number 2, and the Indiction 4, might be properly adapted, none will be found but 4714; becauſe that ſole Number diſtributed into the whole *Period* by 28, without minding the Quotient, leaves 10; divided by 19, leaves 2; and by 15, leaves 4. Therefore the firſt Year of the Chriſtian *Æra* anſwers to 4714 of the *Julian Period*; and the firſt Year of the World will fall on the Year 710 of the ſame Period. If then, which is the more common opinion, the Birth of our Saviour be referr'd to the latter end of the 4000th Year of the World, and precedes by 4 Years the beginning of the common *Æra*; likewiſe if to the Number 4713 of the *Julian Period*, by which is denoted the Year next preceding the beginning of the Chriſtian *Æra*, we add 1700 Years after, which begins from the Year 4714 of the ſame Period, we perfect the ſum 6413: But if we take off 4004 Years of the World from the Number 4714 of the *Julian Period*; both which Numbers, 4004 of the World, and 4714 of the *Julian Period*, agree with the firſt Year of the Chriſtian *Æra*, there will be left the ſum 710: Which ſum, if divided by 28, without any regard to the Quotient, 10 will be left for the *Solar*

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lar Cycle; if by 19, then 7 will be left for the *Lunar Cycle* or *Golden Number*; if by 15, there will remain 5 for the *Indiction*. Likewiſe, if the ſum 6413, which anſwers to the Year of Chriſt 1700, be divided by 28, without minding the Quotient, 1 will remain for the Solar Cycle; if by 19, the remainder will be 10, for the Lunar Cycle; if by 15, then 8 will be left for the Indiction. Therefore, having thus found the Year of the laſt *Julian Period*, which anſwers to every Year before or after the beginning of the Chriſtian *Æra*, we may find with it, the Solar Cycle, the Lunar Cycle, and the Cycle of Indiction, agreeable to that year. Neither is it ſurprizing that the *Julian Period* is ſaid to precede the Creation of the World by 709 Years; ſince it reſults from the multiplication of their Cycles, which have not been all invented together: Neither can they run together, by a common beginning, but within the ſpace of 7980 Years.

I come now to the Third General Head of the Analyſis; which is, To ſhew the Ways of Reckoning among different People, from their particular Diviſion of Time; deduc'd from the Motions and Appearances of the Heavenly Bodies, and from their inſtitutions of Cycles and Periods.

The antient *Egyptians* began their Day at Mid-night, as do alſo the modern Nations of *France*, *Spain*, *Great-Britain*, and moſt parts of *Europe*. The *Jews*, with ſeveral parts of *Germany*, begin their Day at Sun-ſetting; theſe are uſually call'd *Italian* Hours. And the Aſtronomers begin the Day at Noon, and reckon on in a ſeries of 24 Hours, and not twice twelve as we do by our clocks in civil life. The *Babylonians* began their Day at Sun-ſetting, reckoning the Hour immediately before its riſing, the 24th Hour of the Day: From whence the Hours reckon'd in this manner are call'd *Babylonic*.

I have already conſider'd Years, with a view to the principles of *Aſtronomy*, whereon the Diviſion is founded. By this, the various forms of Civil Years, that have antiently obtain'd, or ſtill do obtain, in divers Nations, are to be exhibited. The antient *Roman*

Chronology. Year, which was a Lunar Year, and which was at firſt ſettled by *Romulus*, only conſiſted of ten Months, or 304 Days; which came ſhort of the true Lunar Year by 50 Days, and of the Solar by 61 Days. Hence, the beginning of *Romulus*'s Year was vague, and not confin'd to any preciſe ſeaſon. In order to remove this inconvenience, that Prince order'd ſo many Days to be added yearly, as would make the ſtate of the Heavens correſpond to the firſt Month, without incorporating theſe additional Days, or calling them by the name of any Month. He conſecrated the firſt of his ten Months to *Mars*; whence ariſes its appellation *March*, the ſecond to *Venus*, &c. *Numa Pompilius* corrected this irregular conſtitution of the Year by *Romulus*, and compos'd two new Months, *January* and *February*, of the Days that were us'd to be added to the former Year; the firſt was inſtituted in honour of *Janus*, and the ſecond in honour of *Februus* the God of *Luſtration*. *Numa*'s Year therefore conſiſted of 12 Solar Months, which he adjuſted to ſo many Lunar Months; 6 of them being of 30 Days, and the other 6 of 29 Days; in all 354 Days. But as in this number of Days, the entire Revolution of the Sun could not be accompliſh'd, *Julius Cæſar* thought proper to have 11 Days, and 6 Hours added to it; and therefore made the Year to conſiſt of 365 Days, and 6 Hours, beginning it at the Month of *March*.

The Months therefore ſtood thus: *January* 31, *February* 28, *March* 31, *April* 30, *May* 31, *June* 30, *July* 31, *Auguſt* 31, *September* 30, *October* 31, *November* 30, *December* 31.

Julius Cæſar, to ſupply the defect of 67 Days, which had been loſt through the fault of the Pontifices, and, to fix the beginning of the Year to the Solſtice, made that Year to conſiſt of 15 Months, or 445 Days, which for that reaſon is uſually call'd the Year of Confuſion.

The *Egyptians* had alſo their Year call'd *Nabonaſſar*, which was a Solar Year, conſiſting of 365, divided into 12 Months, of 30 Days each, beſides 5 intercalary Days added at the end. As the *Egyptian* Year, in every four Years, loſes a whole Day of the *Julian* Year,

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Year, its beginning, in the ſpace of 1460 Years, runs through every part of the *Julian* Year; which ſpace, when elaps'd, theſe Years meet again. This Year is us'd by *Ptolemy*, ſo that the knowledge thereof is of uſe in *Aſtronomy*, for comparing the antient obſervations with the modern.

The *Egyptians* being ſubdu'd by the *Romans*, they receiv'd the *Julian* Year, though with ſome alterations: This Year thus reform'd was call'd *Annus Actiacus*, as being inſtituted before the battle of *Actium*. It may not be improper to obſerve here, that when *Julius Cæſar* had conquer'd *Egypt*, where all ſorts of learning, and eſpecially *Aſtronomy*, had long flouriſh'd, he brought with him from thence, a more exact account of a Solar Year, than any that had been us'd before among the *Romans*.

The Year among the antient *Greeks* was Lunar, conſiſting of 12 Months, which at firſt were 30 Days each; then alternately 30 and 29 Days, computed from the firſt appearance of the New Moon, with the addition of the *Emboliſmic* Month of 30 Days, every 3d, 5th, 8th, 11th, 14th, 16th, and 19th Year of a Cycle of 19 Years; in order to keep the New and Full Moons to the ſame time or ſeaſon of the Year; and their Year commenc'd at the Full Moon next after the Summer-Solſtice.

The *Macedonian* Year is divided into antient and modern. The antient *Macedonian* Year is a Lunar Year, only differing from the *Attic* in the names and order of the Months. The modern *Macedonian* Year is a Solar Year, whoſe beginning is fix'd to the firſt of *January* of the *Julian* Year, with which it perfectly agrees. This Year was particularly call'd the *Attic* Year.

The *Jewiſh* Year is alſo divided into antient and modern. The antient *Jewiſh* Year is a Lunar Year, conſiſting commonly of 11 Months, which alternately contain'd 30 and 29 Days. It was made to agree with the Solar Year, either by adding of 11 Days, and ſometimes 12, at the end of the Year, or by an *Emboliſmic*

Chronology. *liſmic* Month. The modern *Jewiſh* Year is likewiſe Lunar, conſiſting, in common Years, of 12 Months; but of 13 in *Emboliſmic* Years, which in a Cycle of 19 Years, are the 3d, 6th, 8th, 11th, 14th, 17th, 19th. Its beginning is fix'd to the New Moon, next after the Autumnal Equinox.

The *Syrian* Year is a Solar Year, having its beginning fix'd to the beginning of *October*, in the *Julian* Year, from which it only differs in the names of the Months.

The *Perſian* Year is likewiſe a Solar Year of 365 Days, conſiſting of 12 Months, of 30 Days each, with 5 intercalary Days at the end. This Year is call'd the *Yezdegerdic* Year, to diſtinguiſh it from the fix'd Solar Year, call'd the *Galalean* Year, which the *Perſians* began to uſe in the Year 1079, and which was form'd by an Intercalation made ſix or ſeven times in four Years, and then once every fifth Year. It may be obſerv'd, that the *Yezdegerdic* Year is the ſame with *Nabonaſſar's* Year. As to the *Galalean* Year, it is abſolutely the beſt, and juſteſt, of all Civil Years yet invented; as being found by calculation to keep the Solſtices and Equinoxes preciſely to the ſame Days, and anſwering very accurately to the Solar Motions.

The *Arabic*, and *Turkiſh* Year, is a Lunar Year, conſiſting of 12 Months, which contain, alternately, 30 and 29 Days; though ſometimes it contains 13 Months. An Intercalary Day is added every 2d, 5th, 7th, 10th, 13th, 15th, 18th, 21ſt, 24th, 26th, 29th, in a Cycle of 29 Years.

The *Ethiopic* Year is a Solar Year, perfectly agreeing with the *Actiac*, except in this, that the names of the Months are different. It commences with the *Egyptian* Year on the 29th of *Auguſt* of the *Julian* Year; and it has 5 Intercalary Days.

The *Jews* uſ'd to give one of their Years the name of *Annus Sabbaticus*, which was every 7th Year; during which Year they let their land lie at reſt: Every 7th Sabbatic Year, that is, every 49th Year, was called

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led the Year of *Jubilee*, which was held with extraordinary ſolemnity.

The Day wherein the Year commences has been as different, in the different Nations above-mentioned, as the Year itſelf; and yet, in all, held in great veneration. The Civil or Legal Year in *England* commences on the Day of the Annunciation, which is on the 25th of *March*; though the Hiſtorical Year begins on the day of the Circumciſion, which is on the firſt of *January*: The part of the year between thoſe terms is expreſs'd both ways, as $175\frac{0}{1}$. *William* the Conqueror having been crown'd on the firſt of *January*; it is ſaid, that day thenceforth became the firſt day of the year for Hiſtorians: Though in all civil affairs, they retain'd the antient way of reckoning, which began with the 25th of *March*. Since the Conqueror's days, the King's Patents, Charters, Proclamations, *&c.* are uſually dated by the year of the King's reign. The Church, as to her ſolemn ſervice, begins the year on the firſt *Sunday* in *Advent*, which is always that next the 30th of *November*, being St. *Andrew*'s day.

The next general diviſion of the *Analyſis* is into that of the application, or accommodation, of *Chronology* to the moſt remarkable *Epocha's*.

As in the Heavens there are certain Points from which the Aſtronomers begin their Computations of the Celeſtial Motions, or inſtants of time from which, as from Roots, all Calculations muſt begin: So all memorable actions are diſpos'd and recorded according to the ſeries of years which will flow from that Root: Theſe Roots are *Epocha's* or *Æra's*, from which we count our years; for in computation of time, we find it neceſſary to fix upon ſome remarkable tranſaction, or memorable event, for the beginning of the reckoning.

According to the Analyſis, this head is divided into *Sacred* and *Prophane*, and further ſubdivided.

The firſt among the Sacred Epocha's, from which the firſt age of the World begins, takes its beginning from the Creation; which is fix'd at the beginning of the

Chronology. the night preceding *Sunday*, *October* the 23d, of the Julian Period, 710; and ends at the year of the World 1656, and almoſt two months of the year 1657. The ſame *Epocha*, according to the Computation of the *Jews*, call'd the *Jewiſh Epocha*, is the year of the Julian Period 953, anſwering to the year before Chriſt 3761, and commencing on the 7th day of *October*. Hence ſubſtracting 953 years from any given year of the Julian Period, the remainder is the year of the *Jewiſh Epocha* correſponding thereto. This *Epocha* is ſtill in uſe among the *Jews*. The *Epocha* of the Creation us'd by the *Greek* Hiſtorians, is the year before the Julian Period 787, anſwering to the year before Chriſt 5501. Hence, to any given year of the Julian Period, adding 787, the ſum gives the year of this *Epocha*. But when it came to be admitted into civil uſe, 8 years were added to it; that ſo every year thereof, divided by 15, might exhibit the *Indiction*, which the Eaſtern Emperors us'd in their Diploma's. The *Epocha* of the Creation us'd by the later *Greeks* and *Ruſſians*, is the year 795 before the Julian Period; or the year 5509 before Chriſt, commencing from the firſt day of *September*; though the *Ruſſians* having lately admitted the Julian Calendar, begin their year from the firſt of *January*. Hence, adding 795 to the year of the Julian Period, the ſum gives the year of this *Epocha*. The *Alexandrian Epocha* of the Creation, is the year 780 before the Julian Period; anſwering to the year before Chriſt 5494; and commencing on the 29th of *Auguſt*. Hence, adding 5494 to the preſent year of Chriſt 1749, gives the preſent year of this *Epocha* 7243 years elapſed, ſince the Creation according to this computation. The *Euſebian Epocha* of the Creation, is the year of the Julian Period 486, anſwering to the year before Chriſt 4228, and commencing in Autumn. Hence, adding 4228 to the preſent year of Chriſt, 1749, the reſult 5977 is the preſent year of this *Epocha*.

The ſecond Sacred *Epocha* is reckon'd from the end of the Deluge, or the beginning of the year of the World 1657, in the 27th of the ſecond month thereof, when *Noah* came out of the Ark, which anſwers to the 18th of our *December*; and ends at the Vocation and Pere-

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regrination of *Abraham*, which happen'd in the year of the World 2083; the 15th of the month *Abib*, which anſwers to the 4th of our *May*; and therefore contains 426 years, 4 months, and 17 days.

The third Sacred *Epocha* is from the Vocation and Departure of *Abraham* from *Haran* in *Meſopotamia*, for the land of *Canaan*; and is continu'd to the Departure of the *Iſraelites* from *Egypt*, that is, to the year of the World 2513, and therefore contains 430 years accompliſhed.

The fourth Sacred *Epocha* begins at the Departure of the *Iſraelites* from *Egypt*, on the 15th day of the month *Abib*, and ends at the time when the *Jews* firſt began to build the Temple of *Jeruſalem*, in the fourth year of *Solomon*'s reign; which correſponds to the year of the World 2992, and thus comprehends 479 years, and 15 days.

The fifth Sacred *Epocha* begins from the foundation of the Temple, and ends with the *Babyloniſh* Captivity; and contains 476 years; *Cyrus* having given leave to the *Jews* to return to *Jeruſalem*, in the year of the World 3468, of the Julian Period 4178.

The ſixth Sacred *Epocha* begins from the time of *Cyrus*'s granting that liberty to the *Jews*, and ends at Chriſt's Nativity, or at the year of the World 4000; and of the Julian Period 4739, which is 532 years. But here it muſt be obſerv'd, that there are two different opinions concerning the number of years elaps'd from the Creation of the World to the Birth of Chriſt: One ſupported by the authority of the *Hebrew* Text, which reckons 4000 years; and the other deduc'd from the computation of the *Septuagint*, and the Hiſtorian *Joſephus*, which makes the Duration of the World to Chriſt's Nativity 5971 years; and this difference, however great, could never be compos'd yet. You may, notwithſtanding, follow the firſt opinion, as the moſt probable; and ſuſpend your judgment concerning the laſt, which has been follow'd by ſeveral of the antient Fathers of the Church. However this difference of

Chronology, computation extends no farther than the Old Teſtament, for it no ways affects the Chriſtian Æra.

The ſeventh and laſt Sacred *Epocha* begins at our Saviour's Birth, and is to continue to the end of the World. There is much uncertainty in the doctrine of time; for according to ſome Chronologers, this *Epocha* begins from the firſt day of *January*, of the Julian year 46; which year agrees with the year 4714 of the Julian Period; ſo that in their Syſtems of Chronology, Chriſt's Nativity is fix'd to the 25th of *December*, of the Julian year 45, and of the Julian Period 4713. But other good Chronologers ſhew, that Chriſt was born four years before this *Dionyſian Epocha*; that is the 25th of *December*, of the Julian year 41, of the Julian Period 4709, and of the World 4000.

This diverſity occaſion'd formerly diſtractions in the Chriſtian Churches; but *Dionyſius*, to compoſe theſe differences, propos'd a new form of the year, with a new general *Æra*, which in a few years time was generally admitted: He began his account from *Lady-Day*, which method ſtill obtains in *Great Britain*. For the vulgar, or moſt commonly receiv'd *Æra* of the Chriſtians, is, the firſt year which follow'd the Biſſextile Julian Year: It happen'd from thence, that from the time of the inſtitution of that *Epocha*, to this our preſent time, every fourth year has been a Biſſextile in the Julian Calendar, as ſettled by *Dionyſius*, who flouriſhed about the year 507. Till his time the generality of Chriſtians computed their years, either from the building of *Rome*, or according to the order of the Emperors and Conſuls, or even from the perſecution of *Diocleſian*; which ſome Authors mark at the year of the common *Æra* 302, and others at the year 303.

But it muſt be obſerv'd that this *Epocha* of *Dionyſius*, is charg'd with a miſtake; the common opinion is, that it places our Saviour's Nativity a year too late; or that he was born the Winter preceding the time preſcrib'd by *Dionyſius* for the Conception or Annunciation, commonly call'd *Lady-Day*. But others obſerve that the fault does not lie in the *Dionyſian Epocha*, but in the miſ-interpretation thereof; however this miſ-interpretation is follow'd in *England*. For *Dionyſius* began his Cycle from

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from the year of the Julian Period 4712; but his *Epocha* from the year 4713, wherein the vulgar *Æra* ſuppoſes Chriſt to have been incarnate. The year therefore, which, according to the vulgar *Epocha*, is the firſt year of Chriſt is, according to *Dionyſius*'s *Æra*, the ſecond; ſo that the preſent year, which we call 1749, ſhould be 1750; and ſome Chronologers, inſtead of one year, will have it two.

To this vulgar *Æra*, as a ſure fix'd Point, Chronologers us'd to reduce all the other *Epocha*'s; though there is not one of them, but what is controverted. There is little reaſon, however, to doubt but this which we now obſerve is the very day; the teſtimony of St. *Chryſoſtom* being clear for the tradition of it. Tho' if there be an error in the computation, the matter of the miſtake being of no greater moment than the falſe calculation of a day, will certainly be very pardonable in thoſe who piouſly celebrate this day. If we entertain our thoughts upon the ſtupendous tenderneſs of God towards Mankind, in ſending ſo wonderful a perſon, we this day commemorate, to accompliſh our Salvation; if we have due tranſports of gratitude for being thus compaſſionately treated; if we make effectual reſolutions of a daily progreſs in piety and virtue, by ſetting a great value upon all the ways of converſing with him in prayer and meditation; if we are more concern'd to hear his ſacred name blaſphem'd, than for any reproach that can be caſt upon ourſelves; if we long for his glorious appearing, that we may enjoy him without interruption to all eternity: If theſe be the pious diſpoſitions of our Souls, the miſtakes of frail Man will by no means affect us in the ſight of that God, who is full of goodneſs to us.

The firſt profane Epocha that was in uſe among the *Greeks*, is that of the *Olympiads*; and had its original from the *Olympick* Games celebrated at the beginning of every 4th year, near the City of *Olympia* in *Peloponneſus*. The firſt *Olympiad* commenc'd, according to ſome Chronologers, in the year 3938, of the *Julian* Period; the year from the Creation 3219; the year before Chriſt 776. Other Chronologers ſay the firſt *Olympiad* commenc'd in the year of the World 3251;

Chronology. the year of the *Julian* Period 3961; and that Chriſt was born in the firſt year of the 188th *Olympiad*.

The ſecond profane Epocha, which was properly that of the *Romans*, began at the building of *Rome*; which was, according to ſome Chronologers, towards the end of the 3d year of the 6th *Olympiad*; which is the year of the *Julian* Period 3964; of the World 3245; before the Chriſtian *Æra* 744: But according to others, of the *Julian* Period 3962. As the *Greeks* us'd to reckon by *Olympiads*, or four years, the *Romans* likewiſe reckon'd by *Luſtra*, or five years, in reſpect to the *Cenſorial* Dignity, which was *quinquennial*; becauſe the Cenſors, every fifth year, which was the laſt of their Magiſtracy, exacted the *Cenſus*, or tribute, impos'd by them on the people.

It is ſaid, that the *Luſtra* were chang'd in *Conſtantine*'s time, into Indictions, which comprehended the ſpace of three *Luſtra*, or 15 years.

If the years of this Epocha be fewer than 754, ſubſtract them from 754, or 753, and you have the year before Chriſt; and on the contrary, if they be more than 754, by adding them to the ſame, the ſum is the number of years ſince Chriſt: And adding the year before Chriſt to 753 or 752, the ſum will give the year of this Epocha.

The third profane Epocha is that of *Nabonaſſar*, King of *Babylon*, and its beginning is mark'd at the 26th of *February*; of the year of the *Julian* Period 3967; of the World 3257; before the Chriſtian *Æra* 747: When *Nabonaſſar*, or *Beleſis*, Governor of *Babylon*, gain'd the Kingdom of *Babylon*. This Epocha is us'd by *Ptolemy* in his Aſtronomical Obſervations, and is compos'd of *Egyptian* years.

The fourth profane Epocha is that of the *Hegira*, or *Mahometan* Epocha, whoſe beginning is taken from *Mahomet*'s flight, which the *Mahometans* call'd *Hegira*, or perſecution; becauſe *Mahomet* had been in ſome dangers, occaſion'd by the novelty of his doctrine. This flight happen'd in the year 5335 of the *Julian*

Period; anſwering to the year of Chriſt 622. This Epocha commences on the 16th of *July,* on a *Friday,* which ſince has been a Holy-Day among theſe people. Chronology.

The fifth is the *Spaniſh* Epocha. The *Spaniards* began to reckon from the beginning of *Auguſtus*'s reign, which was in the 8th *Julian* Year, the 38th before the common *Æra,* and the year of the *Julian* Period 4676; at which time *Auguſtus* began to reign over *Spain,* after the partition of the Empire between him and *Antony.*

The ſixth is the *Yezdegerdic* or *Perſian* Epocha, which is the year of the *Julian* Period 5345, anſwering to the year of Chriſt 632, and commencing on the 16th of *June.*

Having thus given you a general view of the principles of Chronology, I ſhall proceed to exhibit a few Lectures on Hiſtory, or the moſt remarkable events as they ſtand upon the records of time. All actions both good and bad are tranſmitted down to us from the days of old; they are irrevocable, but have different effects: The *Good* give us the higheſt pleaſure, on finding that our Fellow-creatures have acted up to the dignity of human nature; when they have made themſelves thus happy, in immortalizing, as it were, their names, by having executed the commands of Reaſon and the dictates of Religion.

The *Bad,* on the other hand, give us great pain that any part of mankind ſhould thus ſtoop beneath themſelves in committing ſuch baſe actions, which Hiſtory has recorded of them.

Now, it may be worth your while to conſider, that it is your duty to act up to the dignity of human nature, by imitating thoſe ſhining examples in Hiſtory; and by ſo doing you, by having your names tranſmitted down to poſterity on account of your ſuperlative Virtues and Services to Society, will give them the ſame joy, which you feel on reading the characters and actions of thoſe who have gone before you. On the other hand, you may conceive the pain the Generations

Chronology.

rations to come will have, by your means, if your actions have render'd you a plague, a peſt, to the public. And thoſe among you, whoſe actions may not fall under the notice of future Hiſtorians, ought to conſider, that your private Virtues and Vices, are irrevocable; and have different effects too. Vice, when committed, leaves the action in being, but the remembrance thereof is always grievous; and though the action cannot be revers'd, yet through a ſevere attonement, it will not be imputed to us, by that God who is full of tenderneſs and compaſſion to his frail creatures.——Virtue, though often attended with pain, in our ſtruggles to preſerve it, remains upon the records of time, without leaving any uneaſineſs behind it. On the contrary, there ariſes a joy not to be expreſs'd, at the conſciouſneſs of having done well.

In order hereto it may be of importance to you to conſider, that life is but a vapour; the ſpace of ſixty years only a ſpan, a mere point in the ſucceſſion of Generations; an Age appears at the diſtance of yeſterday only, and while we look forwards, for 30 or 40 years, for the completion of our expectations and joys, time is upon the ſwift-wing, and we are grown old without finding what we were ſo earneſtly looking for. This is the caſe with Youth; big with hopes of joys and happineſs, which they are ſure never to meet with, in the light they ſo impatiently expect them.

And with this view we will read and contraſt the public Vices and Virtues of men, who have been conſiderable enough to have fallen under the notice of Hiſtorians: And by comparing them with the true principles of Honour, Reaſon, or Religion, we ſhall ſee how well or ill each perſon, concern'd in the ſtory, has acted his part; and diſcover, perhaps, his views in bringing about the riſe or fall of Empires, Kingdoms, and States; and the revolutions and alterations of Government; as they ſtand pointed out, in the little Treatiſe of Antient and Modern Hiſtory, lately printed for your Uſe.

CHAP. V.

Of PHILOSOPHY.

HITHERTO you have been chiefly employ'd in conſidering the Heavenly Bodies, their wonderful Structure, Motions, Operations, Diſtances, and Magnitudes; and the immeaſurable ſpace they roll in, and what relation they bear to our wants. I ſhall now proceed to lay before you Wonders of another nature; the Conſtitution of the Atmoſphere, or the methods God has appointed, for the preſervation of his creatures, by giving us *the Air to breathe in*; and yet, by a due Ballance, to prevent it from *deſtroying us by its aſtoniſhing Preſſure upon our Bodies*. Philoſophy.

We have already conſider'd the Earth as one of the great maſſes of Matter moving round the Sun; we will now conſider it, as wrapp'd up in the Element of *Air*, as in this Machine before us. In this Air, ſurrounding the Earth, conſtantly float many ſmall Bodies of very different ſorts; and the whole maſs taken together is call'd the *Atmoſphere*.

The Air, excluſive of thoſe particles floating in it, is a ſpringy Body; and that which is neareſt the Earth is compreſs'd by the Weight of all the Atmoſphere that is above it, and reſts perpendicularly upon it. We find that the Air here, near the ſurface of the Earth, is much thicker than it is in the upper Regions, which I ſhall endeavour to explain to you. If upon a fleece of wool, you lay another, the under-one will be a little compreſs'd, by the weight of that which lies upon it; and ſo both of them by a third, and ſo on till a thouſand were pil'd one upon another. The undermoſt would, by the weight of all the reſt, be very much compreſs'd, and all the parts of it would be abundantly cloſer together than when there was no other upon it; and the next to that would be a little leſs compreſt, the third leſs than the ſecond, and ſo on till we come to the uppermoſt, which would be in its full expanſion, and no ways preſs'd together. Juſt ſo is it

Philoſophy. in the Air; the higher you go in it, the leſs it is compreſs'd; and conſequently on the top of all it will be very thin, ſo as to bear an infinitely ſmall Weight or Preſſure upon thoſe parts beneath it.

That the Air is groſſer on the ſurface of the Earth, than in the higher Regions, we conclude from the difference found in the Weight, or Preſſure of the Air, on the tops of the higheſt mountains, and the Weight of it on the lower cavities of the Earth. How high the Air, or Atmoſphere, reaches towards the vaulted roof of the Heavens, is not eaſy to determine; though it is uſually reckon'd about 45 Miles, where the Air is ſuppos'd to have the leaſt ſenſible degree of Preſſure or Weight.

If the Air were equally preſs'd throughout, the Height of the Atmoſphere might be determin'd; but ſince the Preſſure decreaſes the higher we go, the Altitude becomes infinite, and terminates in pure *Æther*. For it is found that the Air is four times more rare at the Height of ſeven Miles, than at the Earth's ſurface; and then the decreaſe of its Preſſure will be in Geometrical proportion to the Altitudes, taken in Arithmetical progreſſion: So that at the Altitudes of 7, 14, 21, 28, 35, 42, 49, &c. the lightneſs of the Air will be 4, 16, 64, 256, 1024, 4096, 16384, &c. Now as a column of Air, upon the Earth, of an Inch ſquare, preſſes or weighs 15 pounds, then a pillar of Air of an Inch ſquare, at the Height of 49 Miles, preſſing the column at that Diſtance, will be the 16384th part of 15 pounds. Since then a pillar of Air, whoſe baſe is a ſquare Inch, weighs 15 pounds, how great muſt the Weight of the Atmoſphere be on the ſurface of the whole Earth! This aſtoniſhing Weight of the Air, you may calculate at your leiſure; by finding how many ſquare Inches the whole ſuperficies of the Earth contains. When we preſent this Scene to our imagination, the Earth thus loaded with ſuch amazing Weight, equally preſſing it on all ſides, with ſuch a dreadful force; we muſt conclude, that it ſurely requires ſome wiſe contrivance, in the Almighty Creator, to keep us from being cruſh'd to pieces with ſuch a terrible Preſſure upon us.—

Suſpend your judgment a while, till we firſt ſhew you a few Experiments, relating to the effects and properties of the Air, neceſſary to be known. Philoſophy.

Experiments to ſhew how neceſſary AIR *is to breathe in, and thereby to preſerve* LIFE.

I. THIS tall Glaſs, call'd a Receiver, being put upon the Plate of the Air-Pump, and making uſe of this mechanical deviſe, we ſhall draw all the Air out of the Glaſs. You now finding the Receiver fix'd faſt down to the plate, it may be worth your while to conſider from whence it proceeds.——The Air was gently drawn out by the contrivance of the Air-Pump. But as the Receiver was moveable before we began; and now being ſo faſt fix'd that it is immoveable; there muſt be ſome cauſe, ſome powerful agent, that has perform'd this! The internal Air being thus taken away, by which the inward parts of the Receiver were ſupported, and the balance taken off, is the cauſe that the Glaſs is thus preſs'd down. You may obſerve in this ſituation, the Receiver cannot be mov'd, for the reaſon before; but upon readmitting the external Air, by turning this cock, and by that means reſtoring the balance, which preſſes as much upwards againſt the inward parts of the Receiver, as the outward parts are preſs'd by the external Air; and therefore the Glaſs may be eaſily remov'd.

That you may not think the Receiver is drawn or ſuck'd down by any thing from within, ſhall be prov'd to you in the next Experiment.

II. Under this large Receiver we will place this ſmall one, at ſome diſtance from the hole thro' which the Air goes out. Now by exhauſting the large Glaſs, the Air will likewiſe make its eſcape from the inſide of the ſmall Receiver. The Air being now exhauſted out of both Receivers, let us conſider the circumſtances.—There is no Air in either of the Glaſſes.——All is free within, and the external Air is preſſing, weighing down or ſqueezing the great Receiver, but the ſmall one within conſequently remains quiet and undiſturb'd by any external preſſure.——What do you think will

Philoſophy. be the conſequence, ſuppoſe I ſhould let in the external Air all at once? You know, from the laſt Experiment, the large Glaſs will by that means be ſet at liberty: And, the Air, being let in ſuddenly, preſſes upon the little Glaſs, and fixes it down, in ſuch a manner, that it is plainly ſeen to ſink into the Leather upon the Plate.

Now as you ſee all this, it entirely prevents any ſuſpicion that ſomething within the great Receiver ſucks or draws it down: But, on the contrary, that it is the internal Air actually taken away from within; and that this ſupport, or prop, being taken out, the balance thereby being deſtroy'd, the external Air preſſes violently upon the Glaſs, which would be broke to pieces by the preſſure, were it not for its ſuperior ſtrength and form.

III. Since then there is ſo great a diminution of the internal Air, by the action of the Air-Pump, what remains being ſo exceeding thin, next to pure Æther, if not an abſolute Vacuum or empty ſpace; let us ſee what will be the effect, by placing this Animal in the Receiver, and taking out the Air, as before. I muſt own it is barbarous to torment the poor Creature thus; bnt we will put it to no more pain, than barely to ſhew you, how neceſſary Air is in general to ſupport God's Creatures.

Upon drawing the Air by degrees out of the Receiver, the Animal, you ſee, grows ſick, and out of order.—-And thus, by exhauſting the Air more and more, it would die in a ſmall ſpace of time.——But, now, upon the re-admiſſion of the external Air, that healing agent in God's hand, the diſtreſſed Animal recovers its former ſtate.—You may have obſerv'd, that the Animal ſwell'd in every part, before the external Air was let into its aſſiſtance.——*Lay this up in your memory, for a future purpoſe:*

Experiments to ſhew the Preſſure *of the* AIR.

I. IF we take theſe Braſs Hemiſpheres, and ſet them one upon another, and fix them upon the Pump; and if we exhauſt the Hemiſpheres, and turn this cock to

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to ſhut out the Air that will be drawn out, they will be preſs'd together ſo much as to require a great force to pull them aſunder, about 140 pounds as you will perceive by applying them to this balance.

II. Now, to ſhew this Experiment another way, we ſhall, as before, fix the Hemiſpheres upon the Plate of the Pump, and draw out the Air as before, and then they will be preſs'd together by the outward Air; and inſtead of applying them to the Arm in the Beam, we will hang one end upon this Hook in the Receiver. You perceive they are ſtill ſqueez'd together by the outward Air as before. What do you think will happen if we exhauſt the Receiver? You know they are kept together by the force of the Air encompaſſing them in the Receiver, before the Pump begins to act: You know alſo there is no Air within the hollow Globe, for that was taken out before. If then we take away the weight of the Air, which thus confines them cloſe together very intimately, there then will be nothing to oppoſe their coming aſunder of themſelves; that is, nothing to prevent the lower Hemiſphere from falling down.—Juſt ſo you perceive it has happen'd; for by my having taken away the 140 pounds, that is, the external Air, they are ſeperated. So then in order to overcome that violence offer'd them in preſſing them thus together, it is the ſame thing, whether I apply them to the Beam and put 140 pounds in the Scale, or take off the force of the Air that acts with ſo much power on them.

You may, from this Experiment, eaſily conceive, that a greater weight will be requir'd, to ſeparate Hemiſpheres of a larger dimenſion than theſe: And ſo, in general, the greater the ſurface of any body, the more weight of Air there is upon it.

III. If we take this Glaſs, which you ſee is open at both ends, of about two inches diameter, and ſet it on the Pump; and if you lay on your Hand, ſo as to cover the Glaſs, you will feel the preſſure of the Air, as we exhauſt the Receiver. For the Air being taken from under your Hand out of the Glaſs, the external Air will preſs your Hand to the Glaſs, ſo that you can

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IV. Another inſtance of the violent preſſure of the Air which ſurrounds us is this. If we ſtretch this wet Bladder over the end of this Glaſs, and tie it and let it dry on; what do you think will be the conſequence? You perceive as the Glaſs now ſtands, no alteration has happen'd to the Bladder; it is quite ſtill and undiſturb'd, and will remain ſo, unleſs, by ſome contrivance, we can take away the very thing that ſupports or keeps it thus ſmooth. It is the inward Air that bears it up; and if we take off the Prop, by exhauſting the Receiver, you will perceive the Bladder to ſink under the weight of the external Air, thus preſſing it down, as your Hand was before, till, for want of the Air beneath, it can no longer bear this outward violence, but burſts with a very great report. You may have obſerv'd, that when the Bladder was preſs'd very much down, it always recover'd its ſmooth ſituation, as ſoon as the Air was let in to ſupport it; but no ſooner did we take away all aſſiſtance than the effect was heard in the noiſe.

V. We will now take this piece of common Window-Glaſs, and fix it upon the Mouth of the Receiver, and ſet it on the Air-Pump. You eaſily conceive what muſt happen.—If you take away what ſupports the Glaſs, the external force will be ſo violent upon it as to break it all to pieces, in the ſame manner as it did the Bladder in the laſt Experiment.

VI. I ſhall take this ſquare Bottle, which has a Valve to ſuffer the Air to come out, but not to return; if I put it in the Cage of Wire, and ſet it on the Air-Pump, with a Receiver over it, and exhauſt the Receiver, the Air in the Bottle will come out through the Valve. And when I have quite taken out the Air, and then let it in again ſuddenly, becauſe the Valve will not ſuffer any to get into the Bottle; when the Receiver is full of Air, the Bottle will, by means of the oppoſition its Valve makes to the Air, remain exhauſted. And becauſe the inward ſides and parts of the

Bottle have loſt their ſupport, the external Air, proving too mighty, will break the Bottle to pieces. Philoſophy.

And now what may your ſentiments be of this powerful agent the Air? You may be ſatisfy'd that ſomething within us muſt ſupport the inward ſides of our bodies, otherwiſe we ſhould be treated moſt dreadfully by this aſtoniſhing preſſure of the Air that ſurrounds us. Suſpend your judgment a little, till we ſhew you how it happens that we are not deſtroy'd, in an inſtant, by this ſurpriſing property of the Air.

Experiments to ſhew that a little AIR *reſiſts, or makes a ſtand againſt, a greater quantity; and that its Spring is equal to its Preſſure or Weight.*

I. AS ſtrange as this may appear to you, yet I ſhall endeavour to ſatisfy you that it is true. For, in order to it, I ſhall fix this ſmall thin and brittle Glaſs Veſſel upon the Plate of the Air-Pump; the ſmall quantity of Air, now remaining incloſ'd therein, makes, you ſee, an equal and compleat reſiſtance againſt the external Air, which is extended from the top of the Atmoſphere down to the Earth; and greatly exceeds the included Air in the ſmall Glaſs-Veſſel, which yet is not hurt thereby, but remains wholly unmov'd between the equal preſſure of the Air within and without. This only happens on account of the exact balance of the internal and external Air, by means of which the Air within preſſes againſt the Glaſs upwards, with juſt as much force, or ſtrength, as the Glaſs is preſs'd downwards, by the external Air over the Glaſs. For when the ſtrength of the internal Air is never ſo little diminiſh'd, by extracting ſome of it by the Air-Pump, you will ſee that the external Air, preſſing upon the outward part of the Glaſs, will affect it in ſuch a manner, as to break it all to pieces; which to effect the like would require ſtrength and ſwiftneſs with the blow of a Hammer.

II. We ſhall next exhauſt this Globe of Glaſs, and by turning this Cock, when the Air is out, it will exclude the external Air; but the ſides of the Glaſs-

Philoſophy. Globe are made thick and ſtrong on purpoſe to prevent its being broke by the great preſſure of the external Air, when the Globe is exhauſted. Now, there is nothing ſupporting the inſide of the Globe, and there is the external Air exerting all its ſtrength on the outſide of the Globe; but it cannot break it, upon account of its ſtrength and ſhape.

Now what do you think will be the conſequence, if I place the Globe thus emptied of its Air, into this Veſſel of Water; and then turn the cock which ſtops the outward Air from having any communication with the inward parts of the Glaſs-Globe? There is no force, ſtrength or reſiſtance, within to ſtruggle or make head againſt any ſuperior ſtrength that offers. Suppoſe I ſhould ſay that the external Air will act with ſo much violence as to throw Water up to a conſiderable height; do you think that the thing is poſſible? You know Water is very heavy, and requires ſtrength to lift it; but then you know, by what you have ſeen, that the Air ſurrounding us is very ſtrong, ſqueezing or breaking every thing wrapp'd up in it, when the ſupports or props on the inſide are taken away. View this Apparatus attentively.——No Air in the Glaſs-Globe; the Air preſſing violently upon the ſurface of the Water in the open Veſſel. Now if I turn the cock which prevents any Air from ruſhing into the Globe, you will immediately find that the Water in the open Veſſel will, by the preſſure of the Air, be driven or forced up in a Pillar of Water, thereby giving way to its violence, and forming a ſwiſt fountain.——This muſt undoubtedly be matter of no ſmall ſurprize to you, that have not been accuſtom'd to theſe effects in nature.

You may ſafely conclude that this effect follows from exhauſting the Air out of the Globe, as the oppoſition, or reſiſtance, is thereby taken away. For otherwiſe, when the Globe is full of Air, this Air, with equal force, makes head againſt, or withſtands, any aſcent of the Water, thus preſs'd upon by the external Air: Becauſe, upon admitting the Air into the Glaſs-Globe, and then plunging it into the Water, there is not the leaſt motion diſcover'd; in the Water, all is ſtill and undiſturb'd, which, being preſs'd upwards and downwards with equal vigour in the Tube, between the two endeavouring powers of the Air within and without the Globe, mutually acting upon each other, is thereby preſerved in perfect tranquility.

III. Again, to ſhew you that a ſmall quantity of Air preſſes equally with the whole external Air; this long Tube ſhall be fix'd in this little Glaſs-Veſſel in which, you ſee, is Mercury. You ſtill obſerve the Mercury to remain in a ſtate of perfect tranquility; becauſe there is as yet no contrivance made uſe of, to alter its preſent ſituation; there being a communication between the open Air and the Mercury, by means of this little hole, and there is a free communication likewiſe with the Tube. Now after ſtopping the little hole with this ſcrew, I ſhall ſet the whole Apparatus under the Receiver; and ſtill you can obſerve no alteration in the Mercury. As the caſe now ſtands, you have the Receiver, and conſequently the Tube full of Air; and the ſmall Glaſs-Veſſel, wherein the Tube is ſcrew'd, ſo as to keep out the external Air, contains Mercury and Air; the latter being ſituated between the top of the Glaſs, and the ſurface of the Mercury. Now what may your thoughts be of the conſequence of this Experiment? —— Suppoſe I ſhould exhauſt the Receiver, and by that means exhauſt the Tube; what then? You know there will be then only a very ſmall quantity of Air included in the ſmall Glaſs-Veſſel above the Mercury, when the Air in the Receiver and the long Tube are ſuppos'd to be exhauſted. The Mercury, that heavy fluid, ſurely cannot fly up the long Tube; and you cannot imagine that the Air, in the Glaſs-Veſſel above the Mercury, will preſs through it, and make its eſcape up the empty Tube and into the Receiver? —— No: But as little a quantity as there is of that Air, it will preſs with that aſtoniſhing violence on the Mercury, as to force it up to a certain height, in this long Tube: And this becauſe the balance of Air, in the open Tube and Receiver, is ſuppos'd to be taken off, by Exhauſtion, or the operation of the Air-Pump. And this you ſhall have the ſatisfaction of ſeeing immediately confirm'd.

Philoſophy. IV. If you conceive the Tube, in this open Glaſs of Mercury, to be exhauſted; then the external Air, preſſing greatly on the ſurface of the Mercury, will force the Mercury up to the height, at which it now ſtands: This Machine is call'd a Barometer. And you may alſo obſerve, that the Mercury in the laſt Experiment is ſupported, by the very ſmall quantity of confin'd Air, in that little Glaſs-veſſel, at the ſame height, as you ſee it ſtands in the Barometer. In the firſt caſe, the Mercury is borne up by a quantity of Air, for example's ſake, as big as a pin's head; this is aſtoniſhing! In the ſecond caſe, the Mercury is ſupported; but by what? Why, by the ſtrength of a pillar of Air, reaching from the ſurface of the Mercury even to the top of the Atmoſphere: So then, in this ſecond caſe, the Mercury being an exact Ballance for the pillar of Air; that is, the Mercury and pillar of Air weighing equally alike, it is no matter which we take for our purpoſe.

Let us then take the Air in both caſes, and compare them together; they both perform the ſame ſervice, in ſupporting the ſame Weight. We have compared the ſmall quantity of Air in the firſt caſe to a pin's head; and to carry on the compariſon, we will compare the pillar of Air, in the ſecond caſe, to this great Globe before us. And yet you ſee this great quantity of Air ſupports no more Weight, in the Barometer, than the exceeding ſmall quantity, bore up in its Tube fitted to that Apparatus. Hence, you may conceive, that let the particle of confin'd Air be never ſo ſmall, yet it will exert itſelf ſo effectually as to be an equal Ballance to any quantity of Air: And this brings me to conſider more particularly, the Spring, Elaſtic Force, or Expanſion of the Air; by which it is effected, that ſuch Weights are ſupported, equally to what is perform'd by a whole pillar of Air.

V. Now in order to underſtand this, in ſome manner, you muſt imagine this Machine, before us, to repreſent a column, or pillar of Air, reaching from the ſurface of the Earth to the top of the Atmoſphere; and conſiſting of a great number of particles, ſuch as A, B, C, D, E, F, G, P, &c. each of which having a cer-

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a certain weight, whereby they preſs upon thoſe that are under them, You muſt likewiſe ſuppoſe, that, in each of them, there is a property, by which, like the Steel Springs of Watches, *&c.* being bent together, they endeavour with the ſame ſtrength that confines them, to recover themſelves from that bent ſituation.

In the Machine before us, the loweſt ſprings, as we may call them P and G, *&c.* bear the weight of all thoſe, that are above them; and, by this means, they are more bent than thoſe that are higher, and which bear a leſſer burden; as A, B, C: For which reaſon the undermoſt P, G, endeavouring more forcibly to reinſtate themſelves, will preſs upon the body I K, which ſupports them, with more violence; as thoſe that ſtand above the body O N, do the ſame. And ſo far the point H bears the weight of the Machine only compos'd of the bent Wires, bearing upon one another, from A to P, preſſing the lowermoſt P G, and bending the ſame.

VI. Now if we proceed to place this frame between the circular Wires, P and G, thereby cutting off, or leaving out, thoſe that are above P, ſtill keeping that Wire exactly bent as when the weight of all the reſt was preſſing upon it; in this caſe, the point H would be equally preſs'd by the Wire P, as if the whole Wires were preſſing with all their weight upon that point. Since then the Wire P is kept in the ſame inflection, when all communication is cut off from the reſt, the upper part of P will preſs equally upwards upon the the point x, as the upper part of P was preſs'd by all the Wires which it bore before. For you cannot bend this *Ring* before us, thus low, but, the moment you take away your Hand, it will return to its former ſituation: And if, inſtead of taking away your Hand, we confine the Ring *thus bent low,* and then put it into this ſlender Machine, and give it full liberty to return to its former ſituation; in endeavouring to effect it the top part of the Machine will be thrown off, by the violence offer'd to it by the motion of the Ring upwards, to recover the figure it had, when nothing preſs'd upon or confin'd it. And if the ſame Ring would require the weight of 50 pounds to bend it, as much as was effected by the Hand, it would preſs upwards againſt

Philoſophy. the Machine, with a force equal to that weight; it therefore preſſes againſt the Hand or againſt the Point z with an equal force.

Now, I think, you may have a pretty good gueſs at what I would endeavour to explain to you; namely, that of the Air's Elaſticity, Springs, or Expanſion.

For let the Machine repreſent the pillar or column of Air. A H, conſiſting from top to bottom of an innumerable number of Particles of Air; ſuch as A, B, C, D, E, F, G, P, *&c.* each of which have a certain weight, whereby they preſs upon thoſe that are under them. In each particle of Air, this property, this Elaſticity like the Steel Springs of Watches, endeavours to recover itſelf from any violence offer'd. Call to mind the Experiment we made to ſhew you, that a little Air reſiſts, or makes a ſtand againſt, a greater quantity. You there found, that a ſmall quantity of Air, incloſ'd in a very brittle Glaſs-Veſſel, made a complete reſiſtance againſt the external Air, extending 45 miles upwards; and by that means the thin Glaſs was preſerv'd whole; for this was effected by the Air within, preſſing againſt the Glaſs with juſt as much ſtrength, as the Glaſs was preſs'd downwards. But in that caſe, when the force of that Air was remov'd by Exhauſtion, then the external Air broke the Glaſs in a thouſand pieces.

Call to mind likewiſe the communication between the open Air and the Mercury, in the other Experiment; that free communication of the column of Air, conſiſting of innumerable Particles, was ſupported by thoſe Particles beneath the Glaſs, and upon the ſurface of the Mercury; and the loweſt of thoſe Particles were preſs'd by, and bore the weight of, the external pillar of Air. Now, inſtead of the Machine to cut off, or leave out the pillar of Air preſſing upon the Baſe of that column, the ſcrew was there fix'd in, by which the communication was effectually cut off; and the ſpring of the included Air preſſed as much againſt the upper part of the Veſſel, as the Baſe of the external Air, left out, preſſed upon the top of the Veſſel. And there the conſequence was, as ſoon as the balance of the Air was taken off by Exhauſtion, the little Air included being then bent, and exerting itſelf to recover, as it were, its liberty, that by its ſpring it rais'd up the Mercury to that height propos'd by that Experiment.

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VII. Again, to ſhew you the Expanſion of the Air, by its Spring or Elaſticity, we will take this Bladder, and ſqueeze out the Air, ſo as to leave only what remains in the folds thereof; and by tying it cloſe, we ſhall prevent the ſmall quantity of Air remaining from making its eſcape, when we exhauſt the Receiver. The conſequence of this will be, that the Air in the Bladder will expand itſelf, ſo as to blow up the Bladder; becauſe the outward parts of it being not preſs'd by the external Air, the Air within endeavours to recover its bent ſprings, and by that means raiſes up the ſides of the Bladder. And that this is ſo, you may conceive, by letting in the Air, for then the Bladder will return to its former ſhape; or in other words, the external Air, preſſing upon the Bladder, preſſes down the internal rarefy'd Air, or bends its ſpring, till it is able to bear the whole weight of the incumbent Air.

VIII. To give you another inſtance how theſe ſprings of the Air, when oppreſs'd or confin'd, will endeavour to ſet themſelves at liberty, we will take this Egg, break off about a third part of the ſhell at the little end, put the yolk and white out of the ſhell; and then at the bottom you may diſcover a ſmall Bubble of Air, between the ſkin and the ſhell. By exhauſting the Receiver, you will ſee the Bubble of Air, by expanding itſelf, will raiſe up the ſkin, ſo as to fill the ſhell, and appear like a whole Egg.

IX. Alſo if we make a ſmall hole in the little end of this Egg, and invert it in this Glaſs, then by exhauſting the Receiver, the Bubble before-mentioned will force all the Egg out of the ſhell through the little hole in the lower end. And if we let in the Air again, the Egg will return again into the ſhell. Now conſider this caſe ——— The external Air acts with all its ſtrength upon the ſurface of the Egg in the Glaſs; but becauſe the expanded or dilated Air, between the ſhell and the ſkin, is not an equal Balance to the external

Philoſophy. Air ruſhing into the Receiver; the ſprings of the confin'd Air, preſs'd by the external Air, are bent ſo much till they become ſufficient to reſiſt the violence offer'd them. And this brings me to conſider the ſpring of the Air in the Pores of Bodies.

You may have obſerv'd, in a former Experiment, that when the external Air preſs'd your Hand to the Glaſs, the inſide of your Hand was ſwell'd downward within the exhauſted Glaſs; and that was effected by the Air in the fleſh of the inſide of your Hand. For when the ſupport of your Hand beneath was taken away, the included Air in your fleſh, by expanding itſelf, or unbending their ſprings, bore down upon the ſkin, and blew it up, as was the caſe with the empty Bladder, when the Receiver was exhauſted.

X. If we take this Apple, which you may obſerve is very much ſhrivel'd, and lay it on the Pump; upon exhauſting the Receiver, the Apple will appear as ſmooth as one freſh gather'd, in its bloom: But upon the readmiſſion of the external Air, it will return to its former wither'd condition.

I think theſe effects are ſo evident, that, you cannot fail, from what has been deliver'd to you, of giving the Philoſophy of them.

Let us conſider the laſt Experiment, and compare it with this.——Air within the ſkin of your Hand, and Air within the ſkin of the Apple; the external Preſſure taken off. The conſequences, in both caſes, were the ſame, the ſkin was ſwell'd up; and both from the ſame cauſe, the external Air taken off, or the balance deſtroy'd, by which the ſprings of the included Air begun to act, and effected their liberty, as far as they could.

XI. Could you imagine that there are Pores in Water, little Vacuities, wherein to lodge the extreme ſmall Particles of Air? That there are in our Fleſh and the Apple you have ſeen. Now, if there be any Air in the Water, we muſt fetch it out, and the effect ought to be viſible, ſo as to leave you no reaſon to doubt of it.

Let us take this ſmall Jarr, wherein there is luke-warm Water; and by exhauſting the Receiver, the Air in the Water will expand itſelf, and raiſe or ſwell the ſmall Portions of watery Particles into Bubbles or ſmall Globes; and the Water, though only luke-warm, will ſeem to boil, and really warm the Receiver, by the diffuſion of its Heat: And, by the re-admiſſion of the external Air, a ſtop will be put to this agitation of the Particles of Air, thus cloathed with watery ſwell'd ſkins. You may perceive, during the aſcent of theſe ſmall Globes, laden with dilated Air, they do not burſt by Expanſion of that Air, becauſe they are equally preſs'd on all ſides by the Water; but when they come to the ſurface of the liquor, the included Air in theſe Bubbles makes them acknowledge its ſuperior ſtrength, by breaking their priſons; but the groſſer Air is carried off, by the action of the Air-Pump; till what remains becomes equal in force to what remains in the Receiver, and which has eſcaped its diligence: For a perfect Vacuum, or empty ſpace, cannot be abſolutely affected by this mechanical device.

XII. I ſhall ſhew you, in the next place, that there is Air even in the Pores of Cork; for if I fix the Lead to the Cork, ſo as to poiſe the latter that it will but juſt ſink in this Jarr of Water before us; as we begin to exhauſt the Receiver, the Air in the Pores of the Cork will expand itſelf, ſo as to ſwell the Cork, and thereby make it ſo light as to make it riſe to the top, or ſwim. Now, in this as in the Apple, upon the re-admiſſion of the external Air, the ſkin or ſurface of the Cork will be preſs'd down every way; that is, the ſprings of the included Air will be ſo far bent, as to become equal in ſtrength to the external weight or preſſure of the Air.

There is, in ſhort, Air in the Pores of all ſolid Bodies; and you may have perceiv'd, in the laſt Experiment of the Cork, that the ſpring of the Air contain'd in the Pores of the Lead, did, by expanding itſelf, appear in Globules; and afforded a pretty ſight, like the pearly drops of dew on the piles of graſs; and which ſuddenly diſappear'd, by letting in the Air again. And here again, you may remember, that the little rarefy'd

Philoſophy. Air remaining in the Receiver, after Exhauſtion, being no more an unequal balance for the rarefy'd Air within thoſe Globes, thoſe Spheres preſerv'd their ſituation; or rather the included Air had not ſtrength enough left to burſt the watery Particles that confin'd it, the preſſure being equal both ways; ſo that the extreme thin ſkin or cover of each Globule was preſerv'd from injury: But upon the re-admiſſion of the external rude Air, this thin watery cover, or weak barrier, was cruſh'd in an inſtant.

Again, XIII. if we put this boil'd Water into the Receiver, and draw out the Air, as much as poſſible, and then put in a piece of raw Fleſh into the Water; and then exhauſting the Receiver, the Air, which is contain'd in the Pores of the Fleſh, will extricate itſelf from its hidden receſſes, and bubble up through the Water, as in former Experiments.

You may have obſerv'd in a former Experiment, that when the Animal was put into the Receiver, and the Air exhauſted, no one part of the poor creature was preſs'd more than the reſt, or rather no one part was preſs'd at all; except we ſhould ſay by the exceeding thin Effluvia, or ſubtle Air, that remain'd after the Receiver was exhauſted, as far as it could be, by that mechanical device, made uſe of in the conſtruction of the Air-Pump. Now then let us conſider this caſe.—— There is no Air in the Receiver, which is able to withſtand, or make any reſiſtance againſt the internal Air pent up in the ſecret Pores of the Animal——This hidden Air, by its ſpring, or endeavour to unbend itſelf, acting vigorouſly againſt the inward part of the Animal's ſkin; and not finding a due reſiſtance from without, the ſkin in this caſe, as in that of the Apple, and Hand upon the mouth of the Glaſs, is forced outward, or ſwelled, and that equally. But upon the readmiſſion of the external Air, that healing and neceſſary agent, the creature is reſtor'd to its ordinnry bulk. And here you muſt make a diſtinction between the Air included in the Fleſh and Pores of the Animal, by which this ſwelling is effected, and the cauſe of the Animal's death; the former proceeding no farther than to diſtort the creature, but the other, the abſence of the wholſome external Air, deprives it of life, or the means of breathing, ſo neceſſary to the preſervation of God's Creatures. Philoſophy.

And now to come nearer our point in view: Let us call to mind the aſtoniſhing preſſure of the external Air upon our bodies. The Element, thus loading us, as it were, preſſing equally upon every part of a Man's body, acts upon him with the weight of 33,684 pounds; for a middle-ſiz'd Man, the ſurface of whoſe body is nearly 15 ſquare feet, carries about him ſuch a weight. This is incredible! What could ſave us from deſtruction, but that balance of power, which God has appointed, whereby one operates juſt as much in our favour, as the other does againſt us?

The Truth is, the Air included in the Pores of our Fleſh, and the Cavities of our bodies, enables us to bear this great weight by its ſpring acting againſt the preſſure of the external Air. Let us attentively view this Machine before us.——You ſee it is perforated with innumerable ſmall holes, which may ſeem to give you a general idea of the exceeding ſmall Pores, Cavities, or ſecret Receſſes in our Fleſh.

Now it is found by Experiment, that a column of Mercury, whoſe Baſe is one inch, ſupported by the external Air, weighs at leaſt 15 pounds. And by allowing 15 ſquare feet for the ſurface of a middle-ſiz'd Man's body, you will have 2160 ſquare inches; and then as each ſquare inch ſupports a pillar of Air of 15 pounds, you have the weight preſſing upon the Man's body: And this even falls ſhort of the true calculation. Let us now ſuppoſe the ſkin of each Pore to be an inch in ſuperficies; then the external Air preſſes the ſurface of the ſkin with a force of 15 pounds; or rather, as the internal Air acts equally againſt it, there is no preſſure at all; for by this happy equality of preſſure, the moſt tender ſubſtances are not affected, but remain ſtill and undiſturb'd.

Again, let us ſuppoſe the ſuperficies of the ſkin, which covers the Pore, to be half an inch; then the pillar of Air will weigh the fourth part of 15 pounds, that is

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Philoſophy. the Elaſticity of the included Air is an equal poiſe to that preſſure. And thus, by diminiſhing in our imagination the ſuperficies of the ſkin which covers the Cell or Cavity, we by that means leſſen the external preſſure above-mentioned. For if we call the ſuperficies of the ſkin a quarter of an inch, the weight of the external column will be the ſixteenth part of 15 pounds: The eighth part of an inch, on the outward ſkin, will have a pillar of Air preſſing upon it of the ſixty-fourth part of 15 pounds: The ſixteenth part of an inch, the weight of the two hundred and fifty-ſixth part of 15 pounds; the two and thirtieth part of an inch, the weight, the thouſand and twenty-fourth part of 15 pounds.

Thus proceeding on, we come to an exceeding ſmall Pore, the Receptacle of an exceeding ſmall Particle of Air; and alſo to its correſpondent extremely ſmall pillar of external Air, whoſe force will be alſo proportionally diminiſh'd.

Let us now conſider the two extreme parts of the foregoing ſuppoſition. The firſt caſe was a ſuppoſition, that the Superficies of the ſkin, covering its Pore, was a ſquare inch, and that ſupported a column of Air, weighing 15 pounds; for whether we take the pillar of Air, or the column of Mercury, it is the ſame thing, as one is an equal balance to the other. The ſecond caſe in that ſuppoſition was, that of an exceeding ſmall Cell, and the extreme ſmall portion of included Air; the ſmall Superficies of the outward ſkin; and the infinitely ſmall pillar of Air, correſpondent thereto. And to theſe two caſes let us take in the whole preſſure of Air upon our bodies, as a third caſe.

In this third caſe, the weight is upwards of 30,000 pounds; not balanc'd by the internal Air in one ſmall Cavity of the body, that is impoſſible; but by the reſiſtance of the included Air confin'd within the ſeperate ſmall Cells, diſpers'd over every point of the body in the ſecond caſe. For to ſay that the included Air, in one of thoſe Pores, balances 33,684 pounds weight, is ſaying what is out of the ordinary courſe of nature to perform, in this caſe, without bending the ſpring of the included Air to that degree, ſo as to deſtroy the

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very Machine which the external Air is appointed to preſerve. Neither are we to imagine, as in the firſt caſe, that the outward column of Air, whoſe Baſe is one ſquare inch, is balanc'd by the internal Air of one entire Cavity; no: But by the union of an infinite number of Particles of Air, contain'd in ſeparate ſmall Cells or Pores, acting againſt the little Baſes of their reſpective pillars of external Air.

Now call to mind again the Experiment we made upon the Apple.—— You remember from its ſhrivell'd condition, it was blown up to be quite plump and ſmooth. There the ſmall Particles of Air, that lay lurking in their little dens, rous'd and exerted themſelves, and buoy'd up the ſkin of the Apple, by relaxing their bent ſprings. And this not from an union of their ſtrength, but ſeparately, each acting upon the extremely ſmall Baſe, of its correſpondent column of external Air; and when that was taken off, by the action of the Air-Pump, then each of them preſs'd upwards, againſt that exceeding ſmall Point, which the ſkin of the Apple ſeparated from the Baſe of the correſpondent column of Air, before it was taken off. And hence you may conceive, from the great Number of theſe Points, the ſmoothneſs and plumpneſs of the Skin was effected; and this may ſerve alſo to give you a tolerable Idea of the cauſe of the Animal's ſwelling, when the Preſſure of the external Air was taken off.

Nor can you, I preſume, be at loſs to conceive in what manner the fleſh of your Hand bagg'd down, when the internal Air was taken away from beneath. And you are now able to gueſs, what the conſequence would be, if the external Air, by any contrivance, could be taken out of this room, ſo as to conſtitute ſuch a Vacuum, as is effected by the Air-Pump.—— In the firſt place, for want of the excluded Air you could not live, as was ſhewn in a former Experiment: And in the next place, your ſkins would be blown up by the Air contain'd in the ſmall Pores of your bodies, as was ſaid before.

But to ſhew you, in ſome manner, how our Lungs may be, perhaps, affected in a Vacuum, I ſhall exhibit

Philoſophy. the following Experiment. Let this ſmall Bladder, tied to this Pipe, and ſcrew'd to this Bottle, repreſent the Lungs and Wind-Pipe. The Air, confin'd in the Bottle about the Bladder, is in the ſame circumſtances with that in the Breaſt about the Lungs. Placing this Apparatus under the Receiver, two or three Vibrations of the handle of the Air-Pump will attenuate the Air in the Receiver, Pipe and Bladder; and the Air in the Bottle will proportionally expand itſelf; or, in other words, its ſpring will endeavour to unbend itſelf, by having ſo much the more room, as there is Air taken out of the Bladder. When we have exhauſted the Receiver, the Bladder will be violently compreſs'd by the Air in the Bottle, by its endeavouring to ſet itſelf at liberty from its bent ſituation.

Let us attentively view the Experiment now before us. There is Air remaining in the folds of the Bladder, which repreſents the Lungs; Air in the Bottle, repreſenting the Breaſt about the Lungs, but confin'd by means of the ſcrew; Air in the Tube, repreſenting the Wind-Pipe, through which there is a communication with the Receiver, alſo full of Air. The Bladder in this ſituation repreſents the Lungs, when we have expell'd the Air in breathing; for when we draw in the Air, the Lungs are extended, or blown up; but emptied upon our forcing the Air out of our Lungs, in the action of Breathing, through the Wind-Pipe. The Spring of the Air, ſhut up in the Cavity of the Breaſt, is more bent when the Bladder is full, and more relax'd, the emptier of Air the Bladder is. Thus when we draw in the Air, the Bladder is thereby blown up, by which the Spring of the Air in the Cavity of the Breaſt is more bent; but upon the expulſion of the Air in the Bladder, by the action of Breathing, the Spring of the Air in the Cavity about the Bladder, unbends its Spring, and thereby preſſes upon the outward parts of the Bladder. But upon exhauſting the Receiver, and thereby exhauſting the Pipe and Bladder, the ſides or outward parts of the latter will be violently compreſs'd, by the Spring of the Air in the Bottle thus endeavouring to unbend itſelf, and to recover its ſtate of liberty. Juſt ſo it would be with us: The Air in the Cavity of the Breaſt, by its Spring, would preſs upon the Lungs, were it poſſible to conſtitute ſuch a Vacuum, as is effected by the Air-Pump. The conſequence whereof would be, as is the caſe with moſt Animals under an exhauſted Receiver, that the Lungs being thus compreſs'd, we ſhould be ſenſible of a prodigious Weight or Preſſure, and expire in the greateſt Agonies of Death. In the former Experiment of the Animal, under the Receiver, you obſerv'd, that as ſoon as we let in the external Air, the poor Creature was thereby reliev'd; the reaſon whereof you may now conceive. For, upon the Re-admiſſion of the external Air, the Lungs, from a compreſs'd ſtate, gradually expand, and that ſo far, till the included Air becomes an equal Balance to the Air in the Cavity of the Breaſt; and then the action of Breathing is reſtor'd, and the Animal thereby recovers its ſuſpended Life.

Now in the light wherein we have ſtated theſe points of Philoſophy, you may conceive that you are able to move freely in the external Air, by means of that wonderful Balance of Power, appointed by the Great Ruler of Nature. For notwithſtanding the vaſt maſs of Air ſurrounding you, what ſhould hinder you from moving?——— You have ſeen, that the number of exceeding ſmall columns of Air, preſſing upon you, is very great, and that their reſpective Weights, or Preſſures, are dwindled away to a *mere Nothing*; and then it is the ſame thing to you, if there were no outward Air thus encompaſſing you, and touching you, with their infinitely ſmall Baſes, on every point of your Bodies.

I ſhould now proceed to ſhew you, that all Bodies whatever, which are of a ſenſible Magnitude, whether they belong to the Foſſil, Vegetable, or Animal Kind, are porous; and that ſome of theſe Bodies, when view'd through a Microſcope, do not ſeem to be compos'd of ſolid parts at all, ſo great is the number of Pores. But this I muſt refer to a more proper Opportunity, when you may be better prepar'd for theſe things.

From theſe and many more Proofs, you may perceive, that unleſs the Air were preſerv'd in its preſent condition, and its due Balance maintain'd, we, and moſt living Creatures, ſhould inevitably and immediately periſh: And this cannot fail to engage our grate-

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ful Acknowledgment to the Divine Being, for ſuch expreſs marks of Care and Goodneſs to his needy Creatures.

Having now finiſh'd what I intend for this *firſt Courſe of Lectures*, I muſt refer you to my *Introduction to the Mathematics*, to acquaint yourſelves, under the Direction of the proper Maſters, with ſome *Principles*, which will be of Importance to you, when we come to *finiſh you* in that genteel, uſeful, and entertaining Part of Education, *Experimental Philoſophy*. And in that *Introduction*, you will alſo meet with the Methods of calculating the Diſtances and Magnitudes of the Heavenly Bodies, and other uſeful, entertaining Problems. I hope, by your Diligence, you will have properly ſtudy'd thoſe *Mathematical Principles*, by the time I have again gone over this *firſt Courſe of Lectures*, with the Pupils under your Age; and then I ſhall proceed according to the *Plan* laid down, in proſecuting thoſe *valuable* Parts of *Education*, too much neglected in the earlier Years of Gentlemen, not only to *their* Diſadvantage, but to the Loſs of the *Public* in general.

FINIS.

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